REPORT

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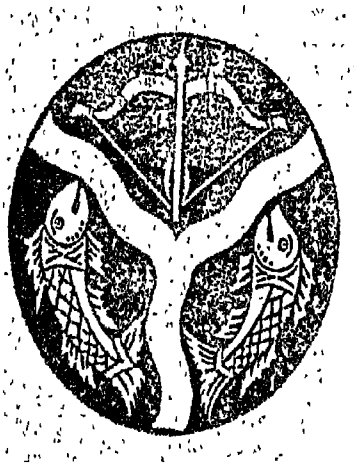
JOINT OWER ALCOHOL AND MOLASSES INQUIRY COMMITTEE

BI AND THE UNITED PROVINCES

1938



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1938

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Report of the Joint Power Alcohol and Molasses Inquiry Committee (Bihar and the United Provinces), 1938

1. *Preliminary*—The Committee was appointed by two identically worded resolutions, one issued by the Government of Bihar, Development Department (No. 2199-D, dated the 22nd December, 1937), and the other by the Government of the United Provinces, Industries Department (No. R/247/XVIII, dated 18th January, 1938). These resolutions were as follows:

"The problems of the sugar industry were discussed at a Joint Conference of the representatives of the United Provinces and Bihar, which was held at Lucknow on the 29th and 30th September, 1937, and by a sub-committee of this Conference which met at Patna on the 19th and 20th October, 1937. One of the recommendations of this sub-committee was that the Governments of the United Provinces and Bihar should set up a joint committee to consider the question of the utilization of molasses for the manufacture of power alcohol and for other profitable purposes. In pursuance of this recommendation, the Government of Bihar, in consultation with the Government of the United Provinces, have decided to appoint a committee to devise ways and means of starting the manufacture of power alcohol out of molasses, to report on the best method of manufacture and of mixing power alcohol with petrol and to explore the possible uses for molasses and their practical application.

"2. The Committee will consist of the following members:

(1) Dr. N. R. Dhar, D.Sc., F.I.C., I.E.S., Professor, Allahabad University.

(2) Mr. G. H. Dickson, Messrs. Begg, Sutherland & Co., Cawnpore.

(3) Mr. Ananthasubramanyam, Mysore Sugar Company, Ltd., Bangalore.

(4) Mr. P. S. Maker, Chief Chemist, Majhaulia Sugar Factory, District Champaran.

(5) Lala Padampat Singhania, Cawnpore.

(6) Mr. M. P. Gandhi, Chief Commercial Manager, The Rohtas Industries, Ltd.

(7) Dr. S. S. Bhatnagar, O.B.E., D.Sc., F. INST. P., Professor, Punjab University, and

(8) Dr. N. G. Chatterji, D.Sc., Harcourt Butler Technological Institute, Cawnpore,

who will also be the Secretary of the Committee.

"The Committee will elect its own Chairman, settle its own procedure and decide whom it will examine."

Further instructions were conveyed to the Committee through the Director of Industries, United Provinces, under the United Provinces Government Order No. 155/XVIII—1180, dated 15th February, 1938, which was as follows:

"I am directed to refer to G. O. No. 155 of 2nd January, 1938, and to say that the Provincial Government would be glad if the Committee appointed to consider the question of the utilization of molasses for the manufacture of power alcohol and for other profitable purposes, would take up the question of power alcohol first and submit its report

on that subject to the Provincial Government by 31st March, 1938, at the latest. The Committee may please be informed accordingly and requested to divide its work into two portions and take up later the question of the utilization of molasses for other profitable purposes."

2. The Committee unanimously elected Lala Padampat Singhania as its Chairman.

3. There were three sittings of the Committee, all held at Cawnpore, on the following dates, viz., on 24th and 25th January, 1938, 7th, 8th and 9th March, 1938, and 16th and 17th April, 1938.

4. In view of the fact that the question of the utilization of molasses, especially through the manufacture of power alcohol, has been widely discussed in India for some years, and has given rise to certain points of a controversial nature, the Committee found it necessary to interpret the terms of reference in a liberal manner. Further, as the public has been taking interest in the subject and as the success of the power alcohol industry would depend upon a favourable reception of the alcohol-petrol mixed fuel by the motorist within the country, the Committee considered that it would be desirable to include a general survey of the various aspects of the industry in this report.

5. Information, both written and verbal, has been obtained from a large number of sources; in some cases on condition that the details or the names of the authority would be withheld from publication. The Committee desires to take this opportunity of expressing its appreciation of the valuable assistance rendered by all those who have so willingly placed authoritative information at its disposal.

6. The report is presented in two sections. Section I deals with Power Alcohol, and Section II with Industrial Alcohol and agricultural and other uses of molasses: viz:

SECTION I—POWER ALCOHOL

(1) Introductory.
(2) Molasses Situation.
(3) Manufacture and Cost.
(4) Economic and Legal Aspects.
(5) Conclusions.

SECTION II—OTHER USES

(1) Introductory.
(2) Industrial Alcohol.
(3) Agricultural Uses.
(4) Other Uses.
(5) Conclusion.

SECTION I—POWER ALCOHOL

INTRODUCTORY

7. The problem of using alcohol as a source of power has been engaging the attention of the scientific world for a long time. Whatever may have been the reasons for promoting the undertaking of this problem in the pre-War days, there is no doubt that at the time of the Great War and thereafter, certain aspects of the problem were brought out in strong relief and led every country to push on energetically with the task of solving it to its

own best advantage. Though each country has some special reasons for its interests in power alcohol, a careful examination of the history and growth of this industry in the more important countries of Europe reveals the following reasons common to all of them:

(i) To minimize the heavy drainage of national wealth out of the country on account of imported petrol.

(ii) The advisability of having a national product as a substitute for petrol in view of the sad experience due to shortage of the latter in the country during the war.

(iii) The necessity of having a large supply of alcohol which is now regarded as an important munition.

(iv) To have an alternative motor fuel available within the country.

(v) The alcohol industry can be made to play a very important part (i) in the prosperity of the agricultural classes, and (ii) in the development of other industries

The development of the automobile industry brought the question of power alcohol into prominence. During the early stages of experimentation on the running of automobiles with alcohol, it was realized that motor car engines designed and constructed for working with petrol could not be run satisfactorily on alcohol alone. Trials with mixtures of hydrocarbons (petrol or benzol) and alcohol, however, gave encouraging results and extensive experiments under technical control were undertaken by the State in France, Germany, Sweden, Czecho-slovakia and Poland.

The result of these experiments was the knowledge that a mixture of petrol or benzol and alcohol in certain proportions can replace, without any disadvantage, pure petrol for automobile driving. Once this fact was established, research work was directed to find out the most suitable composition of the mixed fuel. The practical difficulty was due to the comparative instability of rectified spirit and petrol mixtures, especially in winter temperatures in Europe. It was observed, however, that the range of miscibility improved with the addition of benzol. Later on it was found that absolute alcohol and petrol have a very wide range of miscibility even at low temperatures and the mixed fuels in certain proportions are in no way inferior to pure petrol for use as fuel in motor cars.

With the success achieved in the manufacture of absolute alcohol, the problem of "motor spirit" was not only simplified, but as a matter of fact certain advantages were brought out. Henceforward most of the work in the matter of "power alcohol" was directed in finding out ways and means by suitable legislative, economic and financial measures to bring down the price of alcohol. In spite of vigorous efforts made by the State to encourage the use of "mixed fuels", success was achieved only when legislative measures were passed compelling petrol companies to buy a certain quantity of country-produced alcohol for mixing with petrol. Such compulsory mixing laws are now in force in France, Germany, Hungary, Czecho-slovakia, Yugoslavia and Italy and a number of smaller States. Even in a country like America, where petrol is indigenous and very cheap, the production of alcohol for purposes of fuel has increased considerably, and it is understood that some of the States have under active consideration the introduction of legislation, making the blending of a certain amount of alcohol with petrol compulsory.

A brief account of the legislative measures and practices in other countries is given in Appendix II, paragraph 6.

8. The Committee would now refer to the problem in India.

As far back as 1918, the Indian Industrial Commission, under the chairmanship of Sir Thomas Holland, in their report made recommendations regarding power alcohol in the following words:

> "It is undesirable that the fuel supply of the country should be derived from external sources . . . Petrol is chiefly used in motor cars and small engines which are only intermittently employed. As a source of industrial power it is unimportant, but the demand for it for other purposes is likely to grow, and the provision for a suitable substitute is generally recognized as desirable, if not actually imperative. On several occasions our attention was drawn to the possibility of making industrial alcohol from hitherto neglected vegetable materials, some of which appear to be sufficiently promising to justify investigation and experiment. We recommend that a more liberal policy should be followed by the Excise authorities in respect of the class of denaturant prescribed, and more regard might be paid to the likelihood rather than to the mere possibility of frauds to the revenue, when the requirements of the commercial users conflict with excise regulations." (*Paragraph* 96.)

9. In pursuance of the above recommendation, the Government of India appointed the Industrial Alcohol Committee of 1920 with the following two main terms of reference:

> "(i) to consider and report to what extent and in what respect excise regulations now in force in the different provinces of India regarding the production, sale, storage and transport of industrial alcohol hamper the manufacture in India of such alcohol on a large scale; and
>
> "(ii) to make recommendations for such modifications in those regulations as may be considered necessary, due regard being had on the one hand to the necessity of protecting the Government revenue and also the public safety and on the other hand to the desirability of encouraging the development of the manufacture of industrial alcohol in India."

It may here be pointed out that the term "industrial alcohol" in that report was used in the broader sense, including what is now denoted by the term "power alcohol".

10. One of the recommendations of the Committee was as follows:

> "We therefore suggest that to impose any tax on power alcohol would cripple the industry, which is already handicapped in comparison with petrol. When power alcohol or a mixture of power alcohol and either is mixed with any motor spirit on which duty is payable, the duty should be levied on that constituent only, and not on the power alcohol or on the finished product." (*Paragraph* 125.)

11. This recommendation of the Committee was accepted by the Government of India (resolution no. 6, dated 1st October, 1927, paragraph 4) to the effect that power alcohol should not be handicapped by the imposition of any excise duty except such as should be leviable upon any fuel adjunct which is separately liable to duty.

12. It may, therefore, be concluded that the desirability of encouraging the use of power alcohol in the form of alcohol-petrol mixed fuel had been recognized by the Government of India as early as 1922, when the Industrial Alcohol Committee came to the conclusion that the production of potable spirit and tobacco manufacture easily absorb the entire production of molasses in India, and a surplus for the manufacture of power alcohol was not likely soon to be available. (*Paragraph* 124.)

13. With the rapid growth of the sugar industry in India, molasses became available in large quantities and the prices went down considerably, with the result that the power alcohol question became a matter of vital interest to the cane cultivator and sugar industry. The United Provinces Government, realizing the importance of the problem, deputed in 1933 an officer for the study of the power alcohol industry in the various countries of Europe. In the meantime, the Sugar Committee of the Imperial Council of Agricultural Research as also several Chambers of Commerce in India and the Indian Sugar Mills Association continued from year to year to direct the attention of the Government of India to the urgent necessity for the establishment of this industry in India.

Molasses Situation

14. Molasses is the chief by-product in the sugar industry and it is produced in India from three types of factories, namely, cane-crushing factories, *gur*-refineries, and *khandsaries*. The tables given below have been compiled from official statistics:

(1) *Production of molasses by central factories working with cane*

	1936-37	1935-36	1934-35	1933-34	1932-33
	Tons	Tons	Tons	Tons	Tons
United Provinces	207,930	182,000	125,500	110,052	64,590
Bihar	133,650	97,200	71,878	61,025	57,808
All India	411,640	337,128	233,882	190,381	130,419

(2) *Production of molasses by factories working with gur.*

	1937	1936	1935	1934	1933
	Tons (estd.)	Tons	Tons	Tons	Tons
United Provinces	7,200	20,056	14,166	26,717	40,508
All India	10,600	32,556	21,935	39,770	56,239

(3) *Production of molasses by khandsaris.*

	1936-37	1935-36	1934-35	1933-34	1932-33
	Tons	Tons	Tons	Tons	Tons
All India	100,000	125,000	150,000	200,000	275,000

Khandsari molasses has uses different from factory molasses and the major portion of the former is absorbed in the areas, where it is produced.

15. It would be seen from the statistics that while there has been a rapid fall in the production of *khandsari* and *gur*-refinery molasses, from 275,000 tons and 56,200 tons in 1932-33, to 100,000 tons and 10,600 tons

respectively in 1936-37, there has been an extraordinarily large increase in cane factory molasses, namely from 130,400 tons in 1932-33 to 414,600 tons during 1936-37.

16. While the Committee is unable to ascertain with any degree of exactness the total quantity of surplus cane factory molasses per year in the United Provinces and Bihar, it appears from an official note placed before the Sugar Committee of the Imperial Council of Agricultural Research in 1935 that the internal market for molasses in the whole of India would not be more than 160,000 tons. It is, therefore, estimated that the quantity of surplus molasses produced by the cane factories in India is at present in the neighbourhood of 265,000 tons.* But, due to the fact that about 82 per cent. of the production is in the above-mentioned two provinces, the problem of the utilization of surplus molasses is more serious there than elsewhere.

17. *Export of molasses from India*—In 1935, the sugar industry was given to understand that the Government of India had before them proposals by a firm of standing which had been long engaged in the molasses trade for the installation of the storage and transport equipment necessary for an annual export to the United Kingdom and other countries of about 200,000 tons of molasses. The firm considered that a steady and permanent market was available abroad for the whole of India's surplus molasses, and the Government of India was informed that it would take steps to complete its arrangements for taking up all surplus Indian molasses from the 1935-36 season and onwards. In consequence the Government of India decided not to initiate experiments for the production of power alcohol from molasses on a commercial scale, although advised to do so by the Sugar Committee of the Imperial Council of Agricultural Research in 1933. But they were understood to have given an assurance that they would do so, if at any time in future it should appear that the export scheme referred to above did not provide an adequate solution of the problem of molasses disposal.

18. The hope so entertained by the Government of India regarding the success of the export scheme seems to have fallen far short of the expectations. It is reported that this matter was discussed in May 1937 in the Sugar Committee of the Imperial Council of Agricultural Research, and in view of the disappointing results of the molasses export scheme, a resolution was adopted requesting the Government to issue licences for the production of power alcohol for use as motor fuel in admixture with petrol, to permit the sale of prescribed mixtures of petrol and alcohol for motor fuel, and to modify denaturants so as to permit the substitution of a denaturant suitable for use in motor engines.

19. The following table summarizes some of the information available in connection with the export of molasses in India :

Contracts made by the Molasses Exporting Company	With sugar factories situated in the United Provinces		With sugar factories situated in Bihar	
	1935-36	1936-37	1935-36	1936-37
Quantity purchased (approximate) ..	31,000 tons.	38,000 tons.	12,500 tons.	41,000 tons.
Average price paid f. o. r. factory ..	Rs. a. p. 0 1 0	Rs. a. p. 0 1 0	Rs. a. p. 0 2 1·7	Rs. a. p. 0 1 3·4
Number of factories† reporting sale of molasses	9	12	9	14

*This figure requires modification. Latest statistics for 1937-38 (*Ind Trade Journal*, May 19, 1938) regarding the production of molasses is as follows :

United Provinces	215,700 tons.
Bihar	80,800 ,,
All India	364,000 ,,

†NOTE—It is possible that a few other sugar factories may have sold molasses to the exporting company, but this information was not available.

20. It is significant to note that though the total quantity of molasses purchased by this company during the sugar seasons 1935-36 and 1936-37 was at least 122,500 tons, the quantity actually exported out of India during the period 1st April, 1935 to 31st January, 1938, was only about 88,000 tons. In the event, therefore, of some of this molasses being sold within the country, the relief given to the *surplus* molasses situation becomes to that extent more apparent than real.

PROPERTIES, MANUFACTURE AND COST

21. *Definition*—For purposes of this report, power alcohol is defined as "Dehydrated Ethyl Alcohol of at least 99·4 per cent. by volume." The Committee also suggests that for purposes of measurement, the strength of power alcohol should be reckoned by volume per cent. of ethyl alcohol and not on the basis of London Proof Spirit.

22. *Properties*—Among the common criticisms which have been made against alcohol-petrol fuels in general, the following two seem to have attracted a good deal of attention:

(i) Since alcohol has a calorific value lower than petrol, and since in internal combustion engines the heat energy content of the fuel is converted into power, it follows that alcohol-petrol mixtures must necessarily be less efficient than straight petrol fuels.

(ii) Since alcohol is hygroscopic in nature, there is the possibility of absorption of moisture from the atmosphere, specially in the rainy season by the alcohol-petrol mixture in the storage tanks, even to the extent of the separation of diluted alcohol from petrol into two layers.

23. The essential part of the theoretical and scientific principles regarding the relationship between calorific value of the fuel and power output from it in ordinary motor car engines has been given elsewhere (Appendix I-A). The power value of alcohol-petrol mixed fuel, which is still a subject under controversy, has however been fairly summed up in the following words of Professor A. W. Nash and Donald A. Howes (The Principle of Motor Fuel Preparation and Application, Vol. I, paras. 421—24):

"A point of outstanding importance is that concerning the relationship which exists between the alcohol content of a petrol-alcohol blend and the fuel consumption for a given power output. If the latent heats of petrol and alcohol were the same, this relationship would be linear for any given compression ratio, the fuel consumptions of alcohol and petrol being inversely proportional to their calorific values. However, the large difference existing between these two substances in latent heats is almost as important as the large difference in calorific value and it is the cause of very noteworthy, if somewhat unexpected results.

"The latent heat of a fuel determines, to a large extent, engine volumetric efficiency, and consequently has an effect upon power output. In the case of alcohol fuels, latent heat is of great importance, and has a noticeable effect upon the fuel consumption for a given power output. Professor Hubendick (World Power Conference, London, 1928) made an examination of a range of petrol-alcohol mixtures and showed that the fuel consumption, in terms of heat units, was not appreciably greater with a 20 per cent. ethyl-alcohol blend than with petrol alone, whereas blends containing higher amounts of alcohol gave fuel consumption in proportion to the

alcohol content. As in these tests, no changes in the engine conditions, other than an alteration in carburettor jets, were made, it follows that in blends containing up to 20 per cent. of alcohol, an increase in overall engine efficiency must be compensating for the lower calorific value. This higher overall efficiency is solely caused by the higher latent heats of the alcohol which causes the air consumption per cycle to be increased and so increased the power output.

" With regard to the behaviour of alcohol fuels in ordinary automobiles, therefore, if the alcohol content is kept below 20—25 per cent. by volume, such mixtures may be used with satisfaction without any alteration in carburettor setting and without any alteration in any way to the engine. Such blends will give approximately the same fuel consumption as ordinary petrol and will give about the same power output. Neither starting properties nor engine flexibility will be impaired to any marked degree. If, on the other hand, the alcohol concentration is increased above these limits, power output will be decreased and fuel consumption correspondingly increased, with the result that the blend will not give satisfaction as instanced by the marked unpopularity of " Carburant National " in France, which contains 50 per cent. ethyl alcohol, and the success of " Lattbentyl ", containing only 25 per cent. ethyl alcohol, in Sweden."

24. The Committee has examined some of the data available on the influence of moisture on alcohol-petrol mixed fuels (Appendix I-C). It appears that the absorption of moisture which is likely to take place under ordinary atmospheric conditions in India would not cause the separation of the fuel into two layers, so that as shown by Contant and Mariller [Appendix I-C(2)], there is practically no danger of such separation ever taking place. Besides this, the Committee understands that a mixture of 65 parts of alcohol (96 per cent. by volume) and 35 parts of petrol has been found to be quite stable in Mysore even under monsoon conditions.

25. *No necessity for carburettor changes*—Another point which the Committee thought it advisable to examine in some detail was about the necessity of making any alterations in the adjustment of carburettor of a motor car, when changing over from straight petrol to alcohol-petrol mixed fuel. Opinions of two experts on this subject are as follows:

(1) " The combustion of 1 gramme of alcohol requiring less air than that of 1 gramme of petrol, it may at first sight appear that in running the engine, when pure petrol is replaced by alcohol fuel, the carburettor must necessarily be adjusted, either in increasing the inflow of the fuel or in diminishing the admission of air. Practice, however, has shown that the necessity of such adjustment does not appear. We can cite, for instance, the case of the Poznan Rally of 12th July, 1930, when all runners, having every one covered several hundred miles at high speed using alcohol fuel, stated that they had not had to make any alteration in their carburettors except the usual checkings which the driver can effect without leaving the wheel.

" This fact is explained by the favourable influence of alcohol on combustion. As pure petrol never undergoes complete combustion in the cylinder, all carburettors are usually adjusted for a mixture richer than that established by the chemical theory of combustion, and this adjustment coincides with theory when a certain amount of alcohol is present. "—(Colonel Mayer's " Alcohol Fuels in Poland ", published by the Polish State Alcohol Department.)

(2) Professor Hubendick writes as follows :

" It may be of interest to note that an engine can, without alteration, be operated by turns with petrol and petrol-alcohol blends, provided the alcohol percentage in the mixture does not exceed 20 per cent."

This remark is important in view of the fact that during the initial stages of the introduction of alcohol-petrol mixture, when it may not be available at all places, the motorist will not experience any trouble due to a change in fuel.

This has been amply demonstrated in Europe by motorists when travelling from countries using alcohol-petrol mixtures to those where pure petrol only is used.

26. The Committee would also record here its opinion that the following facts have been established in regard to the properties of motor fuels containing alcohol :

(1) *Alcohol has high anti-knock properties,* so that the addition of some power alcohol to petrol increases the " octane number " of the latter, converting it into a superior grade of motor fuel. This is a very important property, so much so that at present other properties remaining the same, the price of petrol is fixed on its octane number. Increasing the octane number of the fuel by the addition of power alcohol to petrol seems to be a more desirable method for adoption in this country than the addition of " dopes " or complicated blendings with petrol portions from different sources.

(2) *Alcohol has high latent heat and can bear high compression.*

(3) *The addition of alcohol to petrol generally increases the volatility of the latter,* so that engines can be started in the cold more easily with certain alcohol-petrol mixtures than with petrol alone.

(4) *Alcohol-petrol mixed fuels deposit less carbon in the combustion chamber of the engine.* The following quotation from a publication of the Polish State Alcohol Monopoly is of considerable interest :

"The Polish State Alcohol Monopoly organized in July-August, 1930, a long distance automobile test in order to investigate the influence of alcohol fuels upon the wear of the engine.

The tests, strictly controlled by the Polish Automobile Club, was run with an ordinary Chrysler " 66 " car. This car, fed with a 70/30 petrol-alcohol mixture, covered 12,548 miles at an average speed of 34·582 miles per hour. The total time of running was 359 hours 36 minutes, together with an interruption period of 29 hours 20 minutes. The engine had been kept running all the time, even when the car was standing still. The fuel consumption amounted to 3,656 litres or an average of 18·28 litres per 100 kilometres, including halts when the engine was running idle.

At the end of the trial, the main parts of the engine were taken out and examined carefully by the Commission. The following remarks were made :

(*a*) The carbon deposit inside the compression chamber and on the pistons was found to be much less than that usually found when using petrol.

Estimate no. III—Below are given the actual figures of the cost of manufacture of rectified spirit received from a distillery in the United Provinces, producing both " drinking " and " methylated " spirits.

	Per gallon (100 per cent. strength) Rs. a. p.
Cost of molasses at 4 annas per maund	0 1 10·50
Cost of steam, chemicals, labour and staff	0 1 8·73
Warehouse expenses, repairs and renewals to plant, works building and residential quarters, etc.	0 0 5·49
Depreciation	0 0 5·0
Management and administration	0 0 7·72
Cost of per gallon rectified spirit	0 5 1·44
Cost of dehydration (estimated)	0 0 8·68
Total ..	0 5 10·12

Estimate no. IV—The following are the actual audited figures for the cost of manufacture of rectified spirit of 96 per cent. by volume in a distillery in South India producing 325,000 gallons in a year. The rectified spirit is subsequently made into drinking spirit, *arki* and methylated spirit:

	Per gallon of spirit Rs. a. p.
Cost of molasses at 4 annas per maund	0 1 7
Cost of steam, chemicals, power, etc.	0 1 6
Cost of labour	0 0 6
Depreciation, including that on containers	0 1 0
Cost of management	0 0 3
Cost per gallon of rectified spirit	0 4 10

An examination of Estimate no. I reveals that the high cost of manufacture of alcohol is due to (i) the cost of molasses having been taken at As.10-3 per maund, (ii) cost of denaturant at As.1-4·4 per gallon and (iii) cost of depreciation on drums at As.0-7·7 per gallon.

30. For purposes of comparison, therefore, all the estimates have been recast on a uniform basis of cost of molasses at As.4 per maund, while the costs of denaturant and depreciation on containers have been omitted, giving figures for the cost of manufacture of power alcohol, undenatured, in the distillery.

Particulars	Estimate no. I	Estimate no. II	Estimate no. III	Estimate no. IV
	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.
Cost of molasses at 4 annas per maund.	0 1 10·3	0 1 10·0	0 1 10·5	0 1 7
Cost of steam, chemicals, power, labour and staff.	0 2 9·6	0 1 6·6	0 1 8·73	0 2 0
Warehouse charges, depreciation, etc.	..	0 1 2·8	0 0 10·40	0 1 0
Management charges ..	(Not given).	0 0 4·0	0 0 7·72	0 0 3
Cost of dehydration (estimated).	0 1 2·0	0 0 11·28	0 0 8·68	(Not given).
Total ..	0 5 9·9	0 5 10·68	0 5 10·12	..

The total costs in all these estimates received from different sources show close agreement among themselves and also agree almost exactly with the figure of As.5-11 per gallon estimated by the Director, Imperial Institute of Sugar Technology, and given in reply to a question put in the Central Legislative Assembly in March, 1938. The high figures of the estimate

given in the note, dated the 29th September, 1933, by the Secretary, Imperial Council of Agricultural Research (Estimate no. I), were therefore more apparent than real.

31. It would be seen that the cost of molasses is the vital factor in the estimated cost of manufacture of power alcohol. At present the distilleries estimate it at As.4 per maund delivered at the distillery which leaves some margin to themselves. Indeed, one of the distilleries in the United Provinces favourably situated in the sugar factories area, is understood to have contracted at only As.2 per maund, distillery delivery basis. Under the present market conditions, the average price for molasses accepted by the sugar factories from the Molasses Exporting Company is about As.1-2 per maund, so that contracts at As.2 per maund may be considered as quite normal. However, in view of the fact that some distilleries may be situated at a distance from the sugar factory areas, the general practice is to estimate on an average figure of As.4 per maund for molasses. While agreeing that this figure is quite reasonable and there would be no difficulty for the distilleries to get their requirements of molasses at this price, the Committee would like to allow for a high margin of safety, and take for its own estimate the cost of molasses at As.6 per maund delivered at the distillery.

32. After considering the above estimates carefully, the conclusion arrived at by the Committee is that, if a modern plant of sufficiently large capacity (*a*) is established at a suitable place, the cost of manufacture of power alcohol per gallon would be as follows:

	Per gallon of alcohol Rs. a. p.
Cost of molasses at 6 annas per maund at the distillery (with yield of alcohol average of the estimates I, II and III).	0 2 9·15(*b*)
Cost of steam, chemicals, power, labour and staff	0 1 8
Warehouse charges	0 0 3
Depreciation	0 0 7
Management	0 0 2
Cost of dehydration (average of the estimated figures).	0 0 11·3(*b*)
Total ..	0 6 5·18

In case the price of molasses is taken at As.4 per maund, at which it is at present being estimated by the distilleries, the total cost of manufacture of power alcohol would be As.5-6·33 per gallon.

The Committee has also been advised that in a distillery, producing power alcohol directly from fermented wash by the most modern technique, the cost of manufacture of power alcohol would be reduced by about 6 pies per gallon. In other words, the cost of manufacture per gallon of power alcohol would be about (i) As.6 with molasses reckoned at As.6 per maund, and (ii) As.5 with molasses reckoned at As.4 per maund.*

Lastly, the attention of the Committee has been drawn to one of the latest publications† showing in tabular form the comparative costs of dehydration to absolute alcohol by the more extensively adopted commercial processes. The figures given in this table are stated to have been arrived at after careful consideration of all the criticism received since the publica-

(*a*) About 3,000 gallons per day.

(*b*) Revised correct average figures; originally As. 3 and A. 1 respectively.

*Messrs. Ananthasubramanyam and Makor are of opinion that it should be possible to produce absolute alcohol (power alcohol) at price much lower than what is here estimated, when once it comes into actual working but for purposes of calculation, the price here estimated as cost of production, could be accepted.

Needless to mention, the cost of productoin also decreases with increase in the capacity of the plant.

†M. Klar's monograph entitled, "Fabrikation von absolution Alkohol zwock Verwendung als Zusatzmittel zu Motor-Treibstoffen," published by Wilhelm Knapp, Halle, II Edition, 1938.

tion of the first edition in 1936, and their verification from a large number of actual users.—(*Zeitschrift für Spiritusindustrie*, 3rd March, 1938.)

It would be seen that according to this authority the costs of dehydration calculated in rupees per gallon by the Hiag, Melle and Drawinol systems are as follows:

Starting raw material	Salt dehydration Hiag system	Azeotropic Melle system	Azeotropic Drawinol system
	Per gallon Rs. a. p.	Per gallon Rs. a. p.	Per gallon Rs. a. p.
Raw spirit	0 0 0	0 0 8·3	0 0 9·2
Fermented wash	..	0 1 0·5	0 1 5·5

33. *Preparation and distribution of alcohol-petrol mixed fuel*—The success of any scheme for the development of the power alcohol industry depends largely upon an efficient distribution arrangement at low overall cost. It appears to the Committee that this object would be achieved to some extent, if power alcohol is made available for mixing with petrol at a number of railside petrol depots in large consuming centres, the distilleries themselves being located in proximity to them in order to ensure low transportation charges. Further, the transport of power alcohol from the distillery to the petrol depot should be only under bond in tank wagons or lorries. The process of mixing power alcohol with petrol would have to be carried out under excise supervision in accordance with the rules and regulations framed for the purpose by the executive authority. The excise supervision over power alcohol would cease after the mixture has been properly made.

34. *Denaturation*—The question of a suitable denaturant for power alcohol is a matter of vital importance. The commercial success of any power alcohol scheme would depend considerably upon the choice of a denaturant cheap but effective enough to prevent any illicit use of power alcohol. A note on the denaturation of power alcohol, together with a list of denaturants used in various countries is given elsewhere (Appendix XI).

In recommending a suitable denaturant for power alcohol to be adopted in conjunction with the scheme given later, the Committee has been guided among others by the following main considerations:

(i) The denaturant is to be as far as possible an indigenous product easily available, or capable of being manufactured in India.

(ii) In view of the fact that the cost of denaturation is essentially an extra cost, not in any way indispensable in the process of manufacture, it should be kept as low as possible by the adoption of other means to gain the same object as is sought to be achieved by denaturation.

(iii) The recommendation of the Indian Industrial Commission of 1918 to the effect that "more regard might be paid to the *likelihood* rather than to the mere possibility of frauds to the revenue, when the requirements of the commercial users conflict with excise regulations," should be brought more into practice.

(iv) Power alcohol would be made available to the distributors, and through them to the public, only in the form in which it is to be mixed with a large volume of petrol, which is in itself a denaturant.

(v) The storage, distribution and sale of power alcohol in the form of alcohol-petrol mixed fuel would be subjected to the strict regulations and conditions of the Indian Petroleum Act. These would by themselves form an effective safeguard against any attempts at mal practices or abuses.

In case it is found that the addition of a second denaturant (other than petrol itself) is absolutely necessary, the Committee suggests that a trial be given to one of the following :

(1) "Coal-tar Benzole"—3 parts by volume;

(2) "Wood Naphtha"—2·5 parts by volume.

These additions are to be made per 100 volumes of power alcohol.. In the opinion of the Committee alcohol-petrol mixed fuels prepared with power alcohol denatured in this way, would not require any further denaturation. It must however be emphasized that the denaturation of alcohol is essentially a preventive operation against excise offences, and any expense involved in denaturation handicaps to that extent the economic development of the power alcohol industry—a principle which is now recognized in most countries. For example, in the United Kingdom, a denaturation allowance, called "Methylation Allowance", is given to "Industrial Power Alcohol" in order to compensate for the increased cost of the latter due to the compulsory addition of the denaturants.

35. *Sale price of power alcohol*—The Committee is of opinion that power alcohol should be delivered to the petrol distributors at a number of their large storage depots at a uniform price. It is therefore desirable to give an indication of what in its opinion would be a fair price for power alcohol and on the basis of which the retail price for the standard alcohol-petrol mixed fuel may be fixed. In connection with the latter it was necessary to find out the present average cost of distribution of petrol in the United Provinces and Bihar. Unfortunately, the evidence of the representative of the petrol distributing company has not been helpful in this connection. In his oral evidence before the Committee, in answer to the question, "What are your distribution charges per gallon for petrol in the United Provinces and Bihar, which include your capital expenditure, and your interest on the stock you keep and the service you provide on the petroleum distribution in these provinces?", his reply was, "Based on all India charges—licence, inspection, evaporation, excise and commission, it comes to anna 1 per gallon. These charges are bound to change in different provinces. The cost for the United Provinces and Bihar alone, owing to their small petrol offtake, would almost certainly be much higher." Subsequent to the evidence, the Committee was informed that the charge of anna 1 per gallon referred to the extra cost over that incurred in the main ports, and averaged throughout India, of their manifold up-country facilities—such as depots, pumps, lorries, depot and inspection staff, licence, etc. Further inquiries showed that the petrol distributing company estimated that As.6-6 per gallon, when deducted from ex-pump selling price secured for the mixture, would be the maximum price at which power alcohol should be available at the petrol depots for admixture.

The Committee finds that the excise duty is annas 10, railway freight from Calcutta to Cawnpore is annas 4, and the retailers' commission is annas 2 per gallon of petrol. The total of these three items comes to Re.1. The ex-pump price of petrol in April, 1938 at Cawnpore was Re.1-6 per gallon, while the average price for the last year was Re.1-9. The cost of

petrol together with the distribution charges to the retailers' pumps, therefore, works out at annas 6 per gallon based on the present prices, and annas 9 per gallon on the last year's average price. Taking these figures into consideration, the Committee feels that the cost of distribution as given by the above-mentioned company is very high and cannot be accepted. *Dr. Bhatnagar however regrets that, owing to certain assumptions in these calculations—such as the price of the petrol at ports and whether petrol always sells at a profit, he is unable to agree to the above argument. The only way open to the Committee, in his opinion, is either to accept the price quoted by the representative or bring more convincing evidence in favour of the change.* After considering the above observation of Dr. Bhatnagar, the Committee in the last meeting held on 17th April, 1938, arrived at the following conclusion:

> "Assuming the Customs declaration value of imported petrol to be annas 5 per gallon (*see* Appendix II, para. 3), and some profit made by the petrol distributing companies, the distributing charges should work out between As. 2-6 to annas 3 per gallon based on the price of petrol during the last few years. Indeed, according to the present price of petrol ex-pump at Cawnpore, (Re.1-6), the distributing charges can only be about anna 1 per gallon.
>
> "On the above basis, and taking the normal sale price of petrol ex-pump as Re.1-9 per gallon, the estimated sale price ex-pump of power alcohol contained in the alcohol-petrol mixed fuel works out as follows:

	Per gallon Rs. a. p.
Cost of manufacture of power alcohol at the distillery ..	0 7 0
Profit to the distillery	0 1 0
Cost of denaturation	0 1 6
Transportation charges and loss by evaporation ..	0 1 6
Direction and administration charges	0 0 3
Excise duty	0 10 0
Price of power alcohol at the petrol mixing depot ..	1 4 9
Add—	
Distributing company's charges	0 2 9
Retailer's commission	0 2 0
Total ..	1 9 6

Subsequent to the meeting, however, certain facts came to light, which compelled the majority of the members to modify considerably the view expressed above. The c.i.f. price of petrol had been assumed to be annas 5 per gallon, while the Monthly Statistics for the Seaborne Trade in India gives for the period 1st April, 1937 to 31st March, 1938, the average price of petrol from Burma as As. 8-8 per gallon, and that from "Other Countries" as As. 7-9 per gallon.* These figures are considerably higher than the previously assumed figure of annas 5 per gallon, when the import was almost wholly confined to Soviet petrol, and no figures were available for petrol from Burma, as the latter then formed part of India.

The Committee now finds that in view of the Customs declaration made by the petroleum importing companies of the value of petrol at the port of

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* *Import of Petrol into India.*

	Quantity Gallons	Value Rs.
From Burma	63,395,010	3,12,58,430
From other countries	38,660,607	1,88,03,119

entry into India being at least annas 7 per gallon, and allowing for nominal profits only, the average distribution charges all over the country should work out at about annas 2 per gallon based on the price of petrol distributed by them during the last year. Indeed, according to the present price of petrol sold at Cawnpore and other up-country towns, the distribution charges per gallon must have been cut down to a very low figure.

In view of the above facts which make the item of the distributing company's charges an extremely uncertain and controversial item, the Committee thinks it advisable to estimate the sale price of power alcohol only up to the stage when it is delivered at the petrol depot for purposes of mixing with petrol. Further, in view of the fact that the profit of the petrol distributors at the current sale price of petrol appears to be small, the Committee does not feel justified to estimate the "profit to the distillery" at anna 1 per gallon, but to reduce it to pies 6. The cost of manufacture of power alcohol has also been calculated more accurately taking the average of the various estimates, while allowance has been made for the increase in volume due to the addition of the denaturating liquids.

36. The revised estimated sale price of denatured power alcohol delivered at the petrol depots is given below:

	Per gallon Rs. a. p.
Cost of power alcohol at the distillery (with molasses at 6 annas per maund).	0 6 5·5
Profits to the distillery	0 0 6·0
Cost of denaturation	0 0 11·7
Transport charges to petrol mixing depots, loss by evaporation, etc.	0 1 6·0
Direction and administration charges	0 0 3·0
Total ..	0 9 8·2
Add—	
Excise duty	0 10 0
Price of denatured power alcohol delivered at petrol depot	1 3 8·2

In case, however, molasses for power alcohol is taken at annas 4 per maund, the price of power alcohol estimated in the same manner as above would be Re.1-3 per gallon.

The Committee is therefore of opinion that after paying an excise duty of annas 10 per gallon, and incurring an additional burden of the denaturation expenses of about anna 1 per gallon, it would still be possible to deliver power alcohol at the various petrol mixing depots in the two provinces at a price of—

(i) Re.1-3-9 per gallon, after paying annas 6 per maund for molasses, or

(ii) Re.1-3 per gallon, after paying annas 4 per maund for molasses.

37. This may be compared with the cost of imported petrol at the railside petrol depot, say in Cawnpore, calculated as below:

	Per gallon Rs. a. p.
Minimum cost of petrol at Indian port	0 7 0
Excise duty	0 10 0
Railway freight	0 4 0
Total ..	1 5 0

The Committee thus feels satisfied that it would be possible to deliver power alcohol at the large petrol depots at a lower cost than what it takes to bring imported petrol from the port towns.

38. Lastly, it may be mentioned that the Chairman of the Committee has been given assurance that there are several parties who would be quite willing to take up the distribution of the mixed fuel on an overall charge basis of annas 2 per gallon, provided they receive sufficient protection against unfair competition.

ECONOMIC ASPECTS

39. The Committee now proceeds to examine in detail the fiscal and economic aspects of the power alcohol industry which, as recommended, should be developed in the United Provinces and Bihar. Some of the points examined in this connection, and given below, were also raised in the memorandum submitted to it by the representative of the Burma Shell Oil Storage and Distributing Company of India, Ltd.

(1) Legislation for compulsory use of alcohol in motor fuels in other countries has been introduced,

(*a*) to assist the depressed state of agriculture in the case of a few countries; but

(*b*) in most of the countries that have no large petroleum resources of their own, to make themselves less dependent on imported petroleum, and with the further object of economizing in foreign exchange.

(2) In no country the manufacture of home produced substitutes for petroleum spirit and their compulsory sale (mixed with petrol) as a motor fuel, can be justified on economic grounds.

(3) In all the countries the use of power alcohol has been encouraged by State subsidy, direct or indirect. For example, in England (where there is no compulsory legislation for mixing) power alcohol is not only free from the tax of 8*d*. per gallon levied on petrol, but also receives a subsidy from the treasury of 8$\frac{3}{4}$*d*. per gallon in the form a methylating allowance, thus entailing a loss of about £420,000 per year. In France, the annual loss is estimated at about Rs.93,000,000.

(4) The result of using power alcohol has been the same in all the countries, namely—

(*a*) additional expense to the motoring public, and

(*b*) frequently also to the general body of tax-payers.

(5) So long as petrol in sufficient quantities remains available for consumption in the Indian market at anything like the present price, no genuine demand for alcohol as a motor fuel can arise.

(6) It has been urged that the production of power alcohol cannot be profitably developed under present conditions on any material scale without a policy of subsidization.

(7) Burma, despite separation, remains and must remain closely linked to India.

(8) India's full requirements of motor spirit can be met from indigenous and nearby sources of Burma.

(9) If power alcohol is introduced in the United Provinces and Bihar, the total offtake of molasses would be quite small—only 22,000 tons.

(10) No economic advantage can accrue to India from the replacement by a national product (the lower efficiency of which as a motor fuel entails additional running costs) by one obtainable from Burma, Assam and the Punjab at a lower cost.

40. Before proceeding to discuss the various issues raised above, the Committee considers it desirable to review the petrol industry and market in India. Table I gives the annual production of petrol in India and Burma during the last few years.

TABLE I

Production of Petrol

(In gallons)

Official year	In India proper excluding Burma	In Burma	Total for India and Burma
1932-33	Separate figures not available.		68,034,467
1933-34	Ditto		72,612,080
1934-35	17,741,427	63,317,124	81,058,551
1935-36	17,213,311	74,155,870	91,699,220
1936-37	16,736,269	74,352,561	91,088,830
1937-38 (April—December)	11,257,892	..	..

It would be seen that during the period of five years, from 1932 to 1937, the production of petrol in India and Burma has gone up by 23,054,363 gallons. Moreover, since the production in India proper has remained substantially the same for a number of years, it may be concluded that during the period under review the production of Burma petrol has increased by this amount. Since India is the sole outside market for Burma petrol, a very substantial part of this increase must have been absorbed in the India market.

41. Table II gives figures for the import of petrol into India which, when added to figures of production given in Table I, serve to give a fairly accurate idea of the consumption of petrol in India.

TABLE II

Consumption of Petrol

(In gallons)

Official year	Import into India	Production in India including Burma	Total approximate consumption in India and Burma
1932-33	5,116,733	68,034,467	73,151,200
1933-34	1,605,884	72,612,080	74,217,964
1934-35	1,483,274	81,058,551	82,541,825
1935-36	2,077,775	91,699,220	93,776,995
1936-37	9,747,465	91,088,830	100,836,295
1937-38	*102,055,617	..	..

It seems, therefore, that the consumption of petrol in India (including Burma) had of late been increasing at an average rate of about 7 million gallons per year. It also appears that during the year 1937-38, the quantity of petrol of non-Burmese origin imported into India has been about 60 per cent. of that coming from Burma.

*See foot-note on page 35

42. The total offtake of petrol in the United Provinces and Bihar was estimated for the year 1937 by a petrol distributing organization to have been 5½ million and 2¾ million gallons respectively. The Committee, however, thinks that within a couple of years the total quantity for the two provinces would be about 10 million gallons. The estimated consumption of petrol in some of the large towns in the United Provinces and Bihar is given in Appendix X.

43. *Excise duty and the price of petrol at Calcutta*—Excise duty on "motor spirit" levied by the Indian Motor Spirits Duties Act of 1917 was annas 6 per gallon. In 1925, the rate was reduced to annas 4 per gallon, but was again raised to annas 6 per gallon by the Finance Act of 1929. On the recommendations of the Jayakar Road Development Committee, the Government of India Road Fund Resolution of 4th February, 1930, was passed creating a Central Road Fund from the proceeds of the increased amount of the petrol duty, namely annas 2 per gallon. Out of this fund, sums were to be distributed later *pro rata* amongst the different provinces. The Finance Act of September, 1931 increased the duty to annas 8 per gallon, upon which the Supplementary Finance Act of September, 1931 imposed further a surcharge of annas 2 per gallon bringing up the excise duty to a total amount of annas 10 per gallon. Thus, the present excise duty of annas 10 per gallon on petrol is made up of the following different items:

	Per gallon Rs. a. p.
Excise duty proper	.. 0 6 0
Duty allocated to Road Development Fund ..	.. 0 2 0
Surcharge (¼th of the total duty)	.. 0 2 0
Total	.. 0 10 0

The prices of petrol per gallon in bulk at Calcutta, reported in the *Indian Trade Journal*, were as follows:

Period	Price including duty	Rate of duty	Price charged by distributors
	Rs. a. p	Rs. a. p.	Rs. a. p.
Up to February, 1931	1 1 0	0 6 0	0 11 0
From March, 1931	1 3 0	0 8 0	0 11 0
From October, 1931	1 5 0	0 10 0	0 11 0
From August, 1932	1 5 6	0 10 0	0 11 6
From 10th December, 1937	1 2 0	0 10 0	0 8 0

The above table shows that in spite of a large increase in the volume of the trade between 1931 and 1937, the consumer had not been benefited by a reduction in the price he had to pay for his petrol.

44. It has already been shown that power alcohol can be manufactured in the United Provinces and Bihar at a cost of about As.6-6 per gallon, paying annas 6 per maund for molasses. This compares favourably with the present average Customs declaration value of about As.8 pes gallon for imported petrol. When the railway freight to up-country towns is also added on to it, there appears considerable advantage in costs in favour of power alcohol.

The Committee, therefore, is definitely of the opinion that without any kind of subsidy, power alcohol can be marketed in the United Provinces,

in Bihar, and also in other adjoining inland areas at substantially the same price at which petrol is now being sold.

45. The considered views of the Committee on some of the other foregoing points are as follows:

(1) Burma has been separated from India. Imports from Burma cannot therefore be considered as indigenous products of India.

(2) Petrol from indigenous Indian sources, namely—Assam and the Punjab, is hardly sufficient to meet even one-fifth of the requirements of India.

(3) The suggestion that replacing a part of petrol by power alcohol would give a fuel of lower efficiency, entailing additional running costs seems to be contrary to reliable published information on the subject.

46. *Power alcohol and excise duty*—From the Note dated the 29th September, 1933, by the Secretary, Imperial Council of Agricultural Research (Appendix II), it appears that as a result of the examination of this question with the other departments of the Government of India, the following point amongst others was brought out:

> *"Alcohol used for motor spirit must pay the same duty as petrol*—It is not possible for Government to agree to the loss of revenue which any other course would involve, nor would it be reasonable to protect the sugar industry indirectly at the expense of the indigenous oil industry."

But a number of arguments had been placed before the Committee showing the reasons why power alcohol should not be taxed with the same amount of excise or customs duty as petrol. Of these the more important ones are given below:

(i) Power alcohol is essentially an agricultural product manufactured from indigenous sources. The development of this industry is the only practical and economically sound method of supplementing the meagre resources of indigenous motor fuel in this country.

(ii) The indigenous petrol industry of India is not likely to be prejudicially affected by any encouragement given to power alcohol.

(iii) At the rate of annas 6 per maund for molasses at distillery, the indirect help given to the sugar industry would be negligence, especially if the use of power alcohol were to remain confined in the United Provinces and Bihar.

(iv) Between the years 1933 and 1937, the consumption of petrol in India has increased by about 27 million gallons, so that the revenue under petrol excise and customs has increased substantially. A slightly smaller rate of duty on power alcohol would therefore mean only an insignificant loss of revenue to Government. For example, an excise duty at three-quarters the rate on, say, 4 million gallons of power alcohol would affect the revenue to the same extent as if the increase in consumption of petrol had been by 26 million instead of 27 million gallons.

47. Be that as it may, the Committee has estimated that under certain conditions power alcohol, undenatured, can be manufactured at a cost of As.6-6 per gallon, so that power alcohol is in a position to bear the full duty in the interior markets of India of annas 10 per gallon, should the Government require to levy it at the same rate as on petrol.

LEGAL ASPECTS

48. *Power alcohol legislation in foreign countries*—A summary of this is to be found in the Note by the Secretary, Imperial Council of Agricultural Research, to which reference has been made before. The information contained therein has been supplemented further by the Committee (Appendix II-G).

49. *Legislation regarding alcohol-petrol mixed fuel*—This is one of the controversial questions on the subject, and the Committee proposes to deal with it in detail, so as to offer some explanation for the recommendations subsequently made. At the outset it may be said that the Committee considers it desirable that the distribution and sale of the alcohol-petrol mixture should be done through the petrol distributing organizations existing in the country.

The next point to decide is whether there should be some sort of binding obligation for the petrol importers and distributors to use a quantity of alcohol for mixing with petrol. The experience of other countries in this matter has served as a valuable guide to the Committee in coming to a decision.

Of all the countries, Germany struggled very hard not to enforce compulsory mixing legislation, chiefly because the indigenous benzol industry, combined with the State Alcohol Monopoly, undertook the distribution and sale of "Monopoline", the alcohol-benzol mixture. But the foreign petrol groups not only refused to co-operate in any way, but also started an active anti-propaganda against it, so that the Reichskraftverwaltung found a definite setback in the sale of "Monopolin." Therefore the obligatory laws were brought into force from August, 1930. But, as has already been stated, to avoid hardship in special cases, a certain amount of latitude had been left for the petrol importers, in that they had the option of returning the obligatory quota of purchased alcohol to the State at a reduced price; in other words, of compounding the offence of not mixing alcohol with petrol by paying a certain amount of penalty in cash. But this penalty did not act as a deterrent; on the contrary the evil continued to increase so that the privilege had ultimately to be withdrawn and the compulsory mixing had to be rigorously enforced.

In France, on the other hand, though the law of 28th February, 1923, had fixed 10 per cent. as the obligatory quantity of alcohol to be taken by the petrol importers, yet the production of alcohol in the country had been such that the petrol companies were never asked to take more than a fraction of the obligatory quantity. Even then every device was adopted to avoid taking even this small quantity of alcohol, forcing the Government to pass the law by which "Heavy petrol" could not be sold in France except in the form of an alcohol mixture in definite proportions.

The experience of France and Germany about the attitude of petrol groups which follow a uniform policy has been sufficient for other countries like Yugoslavia, Hungary, Italy and others interested in the development of power alcohol to introduce straight away compulsory mixing laws.

50. Taking into consideration various other matters peculiar to conditions in India, as also in view of the fact that almost all the Chambers of Commerce and other commercial bodies have advocated the compulsory mixing of power alcohol with petrol, the Committee is of the opinion that the development of the power alcohol industry requires, during the initial stages at any rate, the sanction of some kind of legislation for the compulsory mixing of power alcohol with petrol before it is retailed to the consumer.

51. *The form of legislation for mixing power alcohol with petrol*—There are three different types of legislation prevailing in Europe enforcing the compulsory use of power alcohol-petrol mixed fuel, namely—

(i) All petrol of a certain grade, whether produced in the country or imported from abroad, is to be marketed only after it has been mixed with alcohol in definite proportions.

(ii) No petrol can be marketed unless it has been mixed with alcohol.

(iii) The petrol companies are obliged to take a quantity of alcohol equal to a certain percentage of the quantity of petrol imported by them during the previous month, and mix it with petrol under definite conditions. Pure petrol can therefore be marketed at the same time as the mixture.

It should be mentioned here that in many European countries there are a large number of special brands of motor fuels, known as super fuels, made of petrol, benzol and alcohol in definite proportions. About 80 per cent. of power alcohol is used in Germany for the making of these special mixtures, every petrol company having its own special brand. There is thus a considerable demand for the special qualities of mixed fuels. Even in the case of petrol, there are marketed several grades differing in specific gravity, volatility and octane number. But, in India the public is accustomed to only one fuel and it would be difficult, at least in the beginning, to get the public accustomed to the idea that an alcohol-petrol fuel is at least as good as pure petrol. It is therefore advisable to have only one kind of mixed fuel for general use.

The form of legislation that may conveniently be adopted should be of the type in which the petrol distributing companies are obliged to take a certain fixed percentage of power alcohol to be mixed with petrol in proportions regulated by executive authority from time to time, and to distribute this mixture in definite localities within which pure petrol should not be distributed

52. *Industrial and power alcohol under the Government of India Act of 1935*—The Committee has thought it desirable to make a general survey of the legal position with regard to the Government of India Act of 1935.

There seems to be considerable doubt about the extent to which the industrial and power alcohol industry can be controlled by provincial legislation. Prior to the Act of 1935, the alcohol industry, both for human consumption and for other purposes was entirely a provincial matter, and provincial legislature had also the right to impose and appropriate to the revenues of the province any excise duty levied on alcohol used for all purposes. For example, in the United Provinces, while alcohol for drinking purposes is subjected to heavy excise duty, methylated spirit or industrial alcohol is free from excise duty. (The recent imposition of a "Sales Fee" is a different matter.)

Section 100, read with Schedule VII, item no. 45, of List I (Federal Legislative List) and item no. 40 of List II (Provincial Legislative List) of the Government of India Act of 1935, now brings about this change that duties of excise on alcoholic liquors for human consumption and alcohol used for "medicinal and toilet preparations" only, can be levied and appropriated by the province where it is manufactured so that by implication or exclusion, duties of excise on alcohol used for other industrial (methylated spirits) and power purposes are to be levied by Federal Legislation and appropriated to the Federal revenues.

53. The Committee is of opinion that with the exception of the rights to levy any excise duty and appropriate it to the provincial revenues, the provincial legislatures and provincial Governments have full rights to control the production, manufacture and development of the alcohol industry for any purpose whatsoever.

This view seems to receive support from the answer given by the Secretary for Education, Health and Lands, Government of India, on 7th September, 1937, in the Central Legislative Assembly to the starred question no. 329, when he said that the Punjab Government had addressed the Government of India in April, 1937, regarding the installation of a plant for this purpose by a certain firm subject to certain conditions, and the answer given by the Government of India was that, in view of the conditions of manufacture mentioned by the firm, the mixture would be liable to the motor excise duty.

54. As regards the question of any provincial legislature to enforce compulsory mixing of power alcohol to petrol, the Committee finds that item no. 32 of the Federal Legislative List makes petroleum a subject of Central legislation, *but only so far as regards possession, storage and transport*. The Petroleum Act (XXX of 1934) deals with the import, transport and storage of petroleum. The tests which petroleum has to undergo under this Act are for the purpose of classification into "dangerous" and "non dangerous" according to flash point determination. The only restrictive measures contained in the Act regarding the addition of another substance to petrol or the "blending" of petroleum are to be found in the following sections:

(i) Section 4(*h*), which prescribes the proportion in which any specified poisonous substance may be added to petroleum, and prohibiting the import, transport or storage of petroleum in which the proportion of any specified poisonous substance exceeds the prescribed proportion;

(ii) Section 5, which prohibits the production, refining and blending of petroleum save in accordance with the rules made under sub-section (2). These rules nos. 130 to 147, relate only to the building, plants, location of storage tanks, drainage, etc., of the refinery, where the process of distillation or blending is performed.

Power alcohol is not a poisonous substance, and as there is at present no restriction in India regarding the quality of the petrol that may be marketed, except with respect to the amount of tetraethyl lead that may be present in it, the Committee is inclined to hold the view that there is nothing either in the Petroleum Act of 1934 or in the Federal Legislative List of the Government of India Act of 1935, which is repugnant to any legislation that may be passed by the provincial Government enforcing the addition of a quantity of power alcohol to all petrol before it is retailed to the public.

55. *Power alcohol industry and Government control*—The Committee has given careful consideration to the question of the advisability of Government control over the power alcohol industry, which has been advocated in some form or other in the memoranda received from the various commercial bodies and associations. Some of the more important arguments advanced in this connexion are given below:

(*a*) The national importance of the industry, the reasons for which it has to be developed in these two provinces, and the diversity of

interests involved in it, demand that the organization and control of the industry be to a large extent under the supervision of the Government.

(*b*) The control of prices and the sanction of law for mixing power alcohol with petrol can be best administered without abuse through the agency of a Government department.

(*c*) The alcohol industry as a whole is so intimately connected with economic and social questions of vital importance to the country that in practically every country in the world the power and industrial alcohol industry is now either under direct State control or is administered through a semi-official organization.

The Committee fully endorses the force of these arguments and is of opinion that the power alcohol industry should be established under the control of the provincial Government with a Power Alcohol Advisory Board to advise the Government generally on all matters connected with the industry. It further holds the view that for the success of the power alcohol industry it is essential that there should be some kind of Government control not only over the manufacture of power alcohol, but also over the distribution, use and retail price of motor fuels within the province. For it is obvious that no amount of Government control over the price of power alcohol delivered at the petrol mixing depots would offer any reasonable protection to the consumer unless there is also some control over the retail price of the mixed alcohol-petrol fuel.

Conclusion

56. The Committee has, in the foregoing pages, dealt with the subject of power alcohol, tracing its growth in the various countries of the world, and also with reference to the importance it has now assumed so far as India is concerned. It has endeavoured to deal with the properties of power alcohol and has, with the materials available, forecasted what the cost of manufacture would be. The Committee has also suggested that it would be possible for power alcohol being produced at a price, which would enable it to bear, if necessary, an excise duty equal in amount to that on petrol without imposing any additional burden either on the tax-payer or the motor owner.

It would be seen that if the entire surplus quantity of molasses, estimated at 265,000 tons, be converted into power alcohol, about 15 million gallons of it can be produced, calculating one ton of molasses as equivalent to 57 gallons of power alcohol. The total consumption of petrol being as high as 100,000,000 gallons, the above-mentioned quantity of power alcohol can be easily utilized, particularly as there would be little difficulty in the disposal of power alcohol in the interior parts of the country, where it can be sold at the same price as petrol. Thus the replacement of 15 million gallons of imported petrol by indigenous power alcohol would mean a saving of about Rs.40 lakhs per year to the country.

The Committee would like to observe here that the case for the development of the power alcohol industry within the country has assumed particular importance with the separation of Burma from India. It appears to be in national interests to encourage the manufacture of power alcohol, and thus to get rid, to such extent as is possible, of the dependence of the country on imported petrol the regular supply of which cannot be assured during an outbreak of hostilities, when it would be in greatest demand.

Power alcohol is an ideal fuel having great flexibility, which makes it possible to be used in higher proportions for heavy types of vehicles. If, therefore, for some reasons, there is a serious shortage of petrol in the country, or if imports are obstructed, or if the price of petroleum which is dependent to some extent on political considerations is enhanced to an uneconomical level, the country would have an alternative supply of fuel, namely power alcohol, to fall back upon.

The Committee estimates that the quantity of petrol consumed in the United Provinces and Bihar will soon reach a figure of 10 million gallons,* so that the requirements of power alcohol for the two provinces will be in the neighbourhood of 2·5 million gallons, for the manufacture of which about 44,000 tons of molasses will be required. But there is no doubt that if a start is made, it will be possible to supply power alcohol to the neighbouring areas as well, and the quantity of molasses so utilized will increase gradually. Although therefore the relief given to the molasses situation in this manner in the initial stages would not be very substantial, there is the certainty that once the industry is established, it will be possible to extend considerably the use of "industrial alcohol" and "methylated spirit", as has been indicated in the following section (Section II). The Committee is thus convinced that the power alcohol industry satisfies all the necessary conditions required for the establishment of a new industry, namely a cheap and abundant supply of raw material in the form of molasses, an adequate supply of labour, and an extensive home market—present as well as potential.

57. *Findings*—The findings of the Committee on various important questions appertaining to the inquiry regarding power alcohol are given below to facilitate reference:

(*a*) The quantity of surplus molasses per annum is estimated at about 265,000 tons† for the whole of India.

(*b*) The scheme for the export of molasses from India has virtually been a failure. The average price received by the sugar factories for molasses in this scheme was anna 1 and pies 2 per maund during 1936-37.

(*c*) (i) The use of power alcohol-petrol fuels mixed in proper proportions in place of straight petrol is not likely to give rise to any trouble and would not ordinarily require any change to be made in the adjustment of the engine or carburettor.

(ii) The use of a 50: 50 power alcohol—heavy petrol mixture in motor lorries and buses may be found to give more satisfaction in tropical countries like India than in Europe.

(iii) Straight alcohol, even of the usual rectified spirit strength, can be used without much trouble in specially designed stationary engines or for running tractors and other agricultural machinery.

(*d*) There are two recognized processes for the manufacture of power alcohol, namely, the Azeotropic and the Salt-dehydration processes. Judging from the number of installations all over the world, both the processes seem to be quite satisfactory.

*In 1937, the off-take of petrol was estimated at 54 million gallons in the United Provinces and 2½ million gallons in Bihar. For figures of consumption of petrol in the various provinces see Appendix II.

†See footnote, paragraph 16

(e) The conditions in the United Provinces and Bihar are very favourable for the manufacture and use of power alcohol made from molasses.

(f) The power alcohol industry can be established without a subsidy from the Government. But, even if it were slightly more costly, the industry should be encouraged, as it would lead to the development of other industries.

(g) Power alcohol can be marketed in the United Provinces and Bihar, as also in the other adjoining inland areas at substantially the same, if not lower, price at which petrol is now being sold.

(h) The average price of petrol, *ex*-pump calculated for most of the large towns in the United Provinces during the greater part of 1937, was Re.1-9 per gallon.

(i) Power alcohol can be manufactured at such a cost that an excise duty almost equal to that on indigenous petrol can be levied on it.

(j) The manufacture of power alcohol seems to be a subject under the control of the provincial Governments.

(k) (i) The cost of manufacture, by the Azeotropic or the Salt-dehydration process, of power alcohol, starting from rectified spirit and excluding the cost of denaturation, would be about As.6-6 per gallon, when the cost of molasses is annas 6 per maund delivered at distillery. By adopting a modified process, it may be possible to bring down the cost to about annas 6 per gallon. Again, in case molasses is available at annas 1 per maund, these prices would further go down by about anna 1 per gallon respectively.

(ii) The price at which power alcohol may be delivered at the petrol mixing depots in these two provinces may not be higher than Re 1-1 per gallon, after paying annas 6 per maund for molasses, anna 1 for denaturants, and annas 10 as excise duty.

(l) The average cost of imported petrol at the railside petrol depot in the United Provinces works out at about Re.1-5 per gallon.

RECOMMENDATIONS

58. The Committee, therefore make the following recommendations:

(a) The power alcohol industry should be established under the control of the provincial Government.

(b) A Power Alcohol Advisory Board should be established consisting of the following:

Chairman.

(1) The Hon'ble Minister in charge of Excise.

Members.

(2) The Excise Commissioner.

(3) The Director of Industries.

(4) One representative of the Provincial Legislative Assembly.

(5) One representative of the Provincial Legislative Council.

(6) One representative of the commercial community nominated by Government.

(7) Two representatives of the Indian Sugar Mills Association.

(8) One representative of the Indian Sugar Syndicate.

(9) One representative of the distilleries manufacturing power alcohol, nominated by Government.

(10) One representative of the distilleries manufacturing industrial alcohol, nominated by Government.

(11) One representative of the motor-fuel distributors in the province, nominated by Government.

(12) One expert nominated by Government.

(Mr. Dickson, however, is of opinion that one representative of the Upper India Chamber of Commerce, and one of the United Provinces Chamber of Commerce should be included in the Board.)

(c) The duties and functions of the Board would be to advise the Government generally on all matters connected with the industry.

(d) Necessary legislation should be enacted at an early date for the compulsory mixture of power alcohol with petrol.

(e) Petrol should not be allowed to be retailed until it has been mixed with power alcohol.

(f) The present petrol distributing organizations in these two provinces should be required to take up the distribution of the mixed fuel. Failing satisfactory arrangements being made with them, the Government should make alternative arrangement for the same.

(g) Power alcohol should be made available at all petrol depots at a uniform price contracted with the Government, inclusive of any excise duty.

(h) Petrol used for admixture with power alcohol should conform to specifications laid down by the Government.

(i) The denaturants for power alcohol may be one of the following:

(1) "Coal tar Benzole"—3 parts by volume, or

(2) Wood-spirit—2·5 parts by volume,

per 100 volumes of power alcohol.

(j) The Government should explore the possibilities of promoting the use of alcohol-mixed fuels for power purposes in agricultural operations, especially in sugarcane areas.

spirit in warehouses by the addition of water, chemicals, or other substances, converts it into various forms of drinking spirit, "methylated spirit", or "specially denatured spirit". It may be mentioned that distilleries equipped with plant for the manufacture of power alcohol can also produce industrial alcohol, but not *vice versa*.

It is estimated, from what has been shown in Section I, para. 32, that the cost of manufacture of industrial alcohol, undenatured, would be about Re.0-5-6 per gallon, after paying for molasses at the rate of 6 annas per maund delivered at the distillery.

62. *Uses*—The various uses of industrial alcohol may be grouped under the following heads:

(1) *As a liquid fuel*, for generating power in slow speed engines mainly for agricultural purposes.

(2) *For household purposes*, chiefly for heating, lighting and cleaning, in the form of what is commonly known as "methylated spirit".

(3) *As a raw material*, required in the manufacture of—

(*a*) Vinegar,

(*b*) Medicinal preparations, such as, tinctures and extracts,

(*c*) Toilet preparations and perfumed lotions,

(*d*) Transparent soap, and

(*e*) Chemicals and other solvents of the ester type;

(4) *As a solvent by itself for*—

(*a*) Shellac and other spirit-varnish preparations,

(*b*) Extraction of oil from seeds and cakes,

(*c*) Extraction of essential oils, and

(*d*) Nitrocellulose preparations.

63. Most of the above-mentioned uses of industrial alcohol are fairly well known, with the possible exception of the use of straight alcohol as a liquid fuel for power generation in internal combustion engines, though this may become an important outlet for industrial alcohol, especially in view of the possibility of the latter becoming available in the United Provinces and Bihar at a low cost. Appendix IV gives the consumption of industrial alcohol for various purposes in some of the more important countries in Europe and America.

It is an established fact that industrial alcohol can be successfully used in internal combustion engines designed for petrol, provided minor adjustments are made and slight difficulties in "starting cold" be neglected, though in specially designed engines with high compression ratio this fuel can be used with better efficiency, and in spite of the considerably lower calorific value the excess fuel consumption per brake-horse power-hour may not be more than one-third that obtained with petrol. (*See* Appendix I-A). The only impediment to the extended use of industrial alcohol for power generation in motor trucks and small engines for agricultural purposes in most countries has been its high cost compared to petrol. But wherever the difference in price is not high, industrial alcohol has been in general use for this purpose as in Poland, Brazil, and the Philippines.

It is understood that experimental work has been undertaken by the Mysore Sugar Company, Limited, on its transport system in the use of an alcohol fuel consisting of spirit of 96 per cent. strength by volume, denatured with $2\frac{1}{2}$ per cent. of petrol and $\frac{1}{2}$ of pyridine and the results obtained are reported to be encouraging. There have been practically no carbon

deposits in the engine, and the high gear performance of the vehicles run on this fuel was found to be very satisfactory.

Reliable data about the cost of generating power in engines specially designed for running on alcohol are not available, but the investigations of Professor Wawrizionik given in Appendix 1-A show that if industrial alcohol be used even in the ordinary low compression petrol engine, the consumption of this fuel would not be more than 0·143 gallon per brake-horse power-hour. There is no doubt that when used in specially designed high compression engines, the fuel consumption would be much better. It therefore, appears that there are great possibilities in the extended use of industrial alcohol for running trucks, agricultural machinery, water-lifting pumps, and small power-plants in isolated rural areas, specially where sugar factories are located.

64. *Household purposes of heating and lighting*—Evidence has been adduced to show that in countries like Czechoslovakia, intensive propaganda has resulted in increasing considerably the use of industrial alcohol for household purposes, such as, for heating and lighting. A certain quantity is also used for cleaning windowpanes and glass showcases. Most of the fully denatured alcohol in Europe is consumed for these purposes. The propaganda for increasing the consumption of the so-called "methylated spirit" has been in the shape of the introduction of cheap but efficient spirit stoves, burners, and lamps. In India also there seems to be considerable scope for the extended use of methylated spirit in this direction and there is no reason why a determined effort should not be made to replace a part of imported kerosene by indigenous alcohol. Modern designs of spirit stoves are in many ways superior to and safer than kerosene stoves, for firstly, they do not work under pressure, and secondly, burning alcohol fire can be easily quenched with water. It is interesting to find that during 1936-37 about 124,500 stoves were imported into India.

The gas mantle industry is getting established in India, and it should be a comparatively easy matter to introduce spirit-burning mantle-lamps. It is possible to make these lamps almost as cheap as the ordinary kerosene ones, and yet get practically as bright a light as is given by the so-called "Petromax" lamps. The price of white kerosene in Cawnpore in bulk is about Re.0-12-6 per gallon, so that it may be possible for methylated spirit to be put in the market at a price which would compare favourably with kerosene even in terms of cost per calorie. This point deserves careful consideration in the problem of street lighting in municipal areas not served by electricity.

While on this subject the attention of the Committee has been drawn to certain experiments carried out in France by the Conservatoire National des Arts at Matiers, in July 1922, with regard to the comparative lighting effect of refined kerosene and a mixture of the same containing 10 parts by volume of absolute alcohol. The results are given below :

Products	Intensity of luminosity in 'candle powers'	Consumption in grammes	Calorific power in calories
(1) Refined kerosene	40	27	11,065
(2) Refined kerosene 90 c.c. Alcohol (99·8 per cent.) 10 c.c. ..	40·9	25	10,000

These experiments seem to receive a certain amount of support from work carried out on the same lines at the Imperial Institute of Sugar Technology. The Committee therefore suggests that this problem may be more thoroughly investigated. If the results are confirmed; a very large field for the consumption of alcohol would get opened up in these two provinces, for the statistics show that the quantity of kerosene imported into the United Provinces during 1936-37 was over 22 million gallons.

65. *Alcohol as a raw material for other industries*—There is no doubt that one of the best and most profitable uses for molasses would be to make alcohol and supply it to the various industries that require it as a raw material. The use of alcohol in medicinal preparations and in making transparent soap is fairly well established in this country. Of the others, the manufacture of vinegar is likely to meet with immediate commercial success. Considerable quantities of alcohol are utilized in Europe for this purpose. In Germany alone, over 2 million gallons of alcohol are converted per year into vinegar. The manufacture of acetic acid and its products is closely related to that of vinegar, and there are considerable potentialities for it, in case the artificial silk industry by the "Acetate process" is established in this country. At the present time, the requirements of acetic acid in India are comparatively small. Attention must also be drawn to the fact that the manufacture of acetic acid by synthetic processes is being largely developed abroad at a price at which it would become increasingly difficult for indigenous acetic acid to compete for use in industries.

Large quantities of alcohol are now being used in the manufacture of organic solvents of the ester type, which are used for dissolving nitrocellulose and resins in the preparation of lacquers. Unfortunately, the nitrocellulose lacquer industry in this country is not yet established and the demand for these commercial solvents in the near future is not likely to be anything substantial. However, it is desirable to keep a close watch over the market for these products and laboratory investigations may be taken in hand to study the commercial possibilities of their manufacture at competitive prices. The use of alcohol as a solvent for shellac and other gums in the preparation of spirit varnish is well known and considerable quantities are being used in India for this purpose. The Committee has been advised that the use of alcohol as a solvent for the extraction of vegetable oils from seeds and cakes is being developed in some countries, while similar investigations are also in progress in the United Provinces. There is no doubt that with a cheap supply of industrial alcohol in the country there are great possibilities for its use as a solvent for extraction and refining purposes. The Committee is of opinion that every facility should be given, from the excise point of view, to encourage experimental investigations for commercial possibilities in these directions

66. In the matter of levying excise duty on industrial alcohol, the policy adopted should be similar to that prevailing in most of the countries of Europe, namely, freedom from or only nominal duty for all kinds of industrial alcohol with the exception of that used in toilet preparations. In support of this policy, the Committee would like to refer to the purchase and sale price of alcohol for different purposes fixed by the State in Germany (*See* Appendix XIII).

II—Agricultural uses

67. (1) *Cattle food preparations*—Various attempts had been made in the past to utilize molasses for feeding cattle, but the results had not been favourable, so that the consensus of opinion now generally held by the experts on the subject in India is that in the raw form it should not be used for this purpose.

Experiments have therefore been undertaken, financed by the Imperial Council of Agricultural Research, to make composite cattle-feed from bagasse screenings, oil-cake and molasses, and to investigate carefully the results of including this composite material in the daily ration of dairy cows and other cattle. The results of these experiments, so far received, have shown that in most cases animals have after a little persuasion been induced to take to it with no marked ill-effects on account of this change in diet from the standard ration. However, there seems to be considerable doubt regarding the economics of feeding molasses to cattle in this way. All that can at present be said is that in case these experiments prove successful and the economic aspects are properly worked out, a considerable outlet for the utilization of molasses through this channel may substantiate in the near future. The results of these experiments should therefore be closely watched by the Agricultural and Veterinary Departments of the two provinces.

In this connexion the attention of the Committee has also been drawn to the proposal of making cattle food from molasses in the form of yeast. Sir John Russell in his "Report on the work of the Imperial Council of Agricultural Research in applying science to Crop Production in India", 1937 (page 13), refers to this subject in the following words:

> "The possibilities of utilization fall into three groups—
>
> (1) Conversion into food (including yeast) for human beings or for animals;
>
> (2) The making of fermentation products, such as industrial alcohol, acetic acid; and
>
> (3) Industrial utilization as fuel, road surfacing material, fertilizer, etc.
>
> Of these I regard the first and second as the most important and the third as the least important; it seems unfortunate to divert so much potential food to other purposes."

68. Composite cattle-feed preparations are somewhat cumbrous to manufacture, and involve comparatively heavy expenditure on account of transportation charges. Yeast, on the other hand, is proteid matter in a highly concentrated compact form, easy to transport, while a very small quantity need be given at a time to the animal in the daily ration. The advantage of making cattle-food yeast is that the latter is a by-product of the alcohol industry, and its manufacture can be easily carried on in every distillery with a slight change in the early stages of the process. The manufacture of the two products—Alcohol and Yeast—can therefore be brought under one single organization, giving a certain amount of latitude for adjusment of their prices. The manufacturing process is also so flexible that the relative quantities of the two products obtained from a fixed quantity of molasses can be regulated to a large extent in order to suit marketing conditions. It may be interesting to note that to produce the same quantity of alcohol, almost three times the quantity of molasses may be utilized, if the manufacture of yeast is also being carried on at the time. It is thus possible that by a judicious organization of the manufacture and sale of alcohol and yeast, the problem of surplus molasses so acute in the congested areas of sugar factories may be capable of a comparatively easy solution.

69. The Committee therefore suggests that in initiating any comprehensive scheme for the development of the alcohol industry in these provinces, where there is likely to be an excessive surplus of molasses, the Government should seriously consider the economic possibilities of linking up a number of small yeast-making distilleries attached to sugar factories, with larger distilleries located at more central places, rectifying the raw alcohol supplied by the former.

70. (2) *Manure and fertilizer*, and

(3) *For reclaiming usar soils*—The utilization of molasses for these two purposes seems to have been the subject of a fair amount of experimentation in different parts of India and abroad. The subject has, in recent years, been widely discussed in scientific circles, leaving no doubt about the great interest aroused in the matter. The Committee therefore tried to get the most authentic information about the results of the experiments carried out by the Agricultural Departments in the various provinces, who were also requested to give their views regarding the extent to which they were prepared to recommend the use of molasses for these purposes. Unfortunately the reports received have been of a somewhat conflicting nature and the Committee feels considerable hesitation in arriving at any conclusions in these matters. It is reported that the Government of the United Provinces are thinking of appointing a special committee to enquire into the question of the manurial value of molasses. In the opinion of one of the members of the Committee (Dr. N. R. Dhar), the use of molasses as manure with a view to increase the yield of crops has been proved beyond doubt in the case of rice and possibly also in the case of sugarcane. The economic aspects of the proposition, however, need further investigation in view of the transport difficulties. As regards the application of molasses for reclaiming *usar* soils, he considers that it has met with uniform success in various provinces, particularly in Bihar and the United Provinces as also in Mysore, from where it has been reported to him that *usar* lands, which had been treated with molasses three years before, continued to give a good crop of paddy, average yield being 1,250 lb. per acre. Thus it seems that the proposal to reclaim *usar* soils by the addition of molasses has gained a certain amount of support from some quarters, and systematic field investigations have been taken up at many places to verify the results claimed for the process in comparison with other well known processes. Further, the Committee has been given to understand that investigations on this subject are shortly to be undertaken in the United Provinces, financed by a special grant made by the Government for the purpose.

A summary of the reports received from the various Agricultural Departments in reply to the enquiry made by the Committee is given in Appendix XVIII-(A—E).

71. The Committee as a whole is not in a position to express any definite opinion in the matter, but would like to mention that the Agricultural Departments of the United Provinces and of Bihar should take interest in the subject and continue their experiments with the reclaiming of alkali soils by the use of molasses or a mixture of molasses and press-mud.

III—Other Industrial uses of Molasses

72. (a) *As fuel*—Attempts had been made in some factories for burning molasses under the boiler as a supplementary fuel, when it could not be disposed of in any other way. Without entering into the merits or otherwise of molasses as fuel, the general opinion on this use of molasses is well expressed in the following words: "It is a pity to throw away molasses in this way"—an opinion with which the Committee finds itself in full agreement.

(b) *Road composition and road surfacing material*—A few years ago, attempts were made in Mysore to use solutions of molasses in water in consolidating roads subjected to heavy traffic, but were subsequently given up. The attention of the Committee was invited to the investigations in this

direction being carried out at the Imperial Institute of Sugar Technology, Cawnpore, and which were reported in the *Indian Trade Journal Supplement*, dated 10th February, 1938. The Committee however is of opinion that though the possibilities in this line of investigation are great, the work is yet in the early stages of experimentation, and it is not likely that in the immediate future a substantial outlet for molasses would be found for this purpose.

(*c*) *Plastics and resinous material*—The subject of utilizing molasses in the making of plastics and resinous material seems to be still in the laboratory stage and no information was available to the Committee in this matter.

(*d*) *Fermentation products other than alcohol or yeast*—It seems that a fair amount of work has been carried out in some countries on the production of substances other than alcohol and yeast by conducting the fermentation of molasses by special methods. Lactic acid, citric acid, and glycerine are reported to be some of these products which are being made commercially by the fermentation of molasses.

73. The Committee is not in a position to make any comments but feels sure that any commercial enterprise that takes up the manufacture of chemicals and commercial solvents from molasses is bound to extend its activities into the possibilities in this direction.

FINDINGS

74. The findings of the Committee on various important questions with regard to the uses of industrial alcohol and also of molasses for other industrial and agricultural purposes are given below:

(1) There is a large field in India for expansion in the use of alcohol for industrial purposes.

(2) The use of "methylated spirit" for purposes of heating and lighting may be considerably increased by suitable propaganda, especially when there is possibility of marketing it at a price competitive with kerosene.

(3) The "Vend-fee" of 8 annas per gallon levied on methylated spirit is very high as compared with the excise duty on kerosene.

(4) The high rate of "Vend-fee" on methylated spirit is a great handicap against its more general use.

(5) The present market in India for vinegar, acetic acid, commercial organic solvents, and such other products wherein alcohol is used as a raw material, is small, but is capable of being developed.

(6) The use of molasses as a fuel is unremunerative.

(7) The use of molasses for making road compositions is still in the early stages of experimentation.

(8) Investigations regarding the utilization of molasses for making composite cattle-feed have so far not given any discouraging result.

(9) Yeast for cattle-feed can be manufactured from molasses at the same time as alcohol, and the economic possibilities in this direction seem to be attractive.

(10) The use of molasses as manure in normal soils has not received much support from the majority of agricultural experts in India.

(11) The use of molasses for reclaiming *usar* soils has aroused considerable interest and is being tried in different parts of India. At many places encouraging results have been obtained and extended trials are being given to this process of reclamation.

RECOMMENDATIONS

75. (1) "Industrial Alcohol" for use in internal combustion engines should be (i) more heavily denatured than power alcohol; (ii) free from any kind of excise duty; and (iii) sold at almost the cost price.

(2) Research work should be undertaken by the Government on all technical matters connected with the use of industrial alcohol for power generation in stationary engines, tractors and lorries.

(3) Intensive propaganda work should be done to popularize the use of methylated spirit for household purposes, such as for heating and lighting.

(4) Facilities should be given by the Excise Department to encourage experimental investigations for the commercial use of industrial alcohol for solvent and other purposes.

(5) Investigation should be made into the commercial and practical possibilities of combining the manufacture of alcohol with that of yeast for cattle feeding.

(6) The results of the experiments now being carried out under the Imperial Council of Agricultural Research on (i) the feeding of cattle with bagasse-oilcake-molasses cakes, and (ii) road-making and surfacing compositions, should be closely watched by the Government, as these uses may form in future substantial outlets for molasses.

(7) The Agricultural Departments of the two provinces should give an exhaustive trial to the method of reclaiming *usar* soils by the application of molasses, and study carefully the economic aspects.

CONCLUDING REMARKS

76. The terms of reference to the Committee are as follows:

(1) To advise on the manufacture of power alcohol out of molasses;

(2) To report on the best method of manufacture;

(3) To report on the best method of manufacturing petrol-alcohol mixture; and

(4) To explore the possibilities of the use of molasses in other practical applications.

Under the first heading the Committee has stated that the manufacture of power alcohol out of molasses is a feasible proposition, being an economic one, and that power alcohol could be manufactured and sold in the United Provinces and Bihar, and in other interior places, at a price which could be less than the present selling price of petrol, and which could bear, if necessary, the same excise duty as the Government of India may levy on petrol.

The Committee feels that the best method of developing this industry, which is an important one, would be by introducing legislation in the United Provinces and Bihar, and in such other provinces as would like to do so, making it compulsory for all petrol sold in these provinces, to be mixed with power alcohol in a definite proportion, say, 20 per cent. by volume of power alcohol.

The petrol-alcohol mixture should be prepared under Government supervision, which could be effectively done by the entire production and distribution being regulated by an Advisory Body referred to elsewhere.

As regards the best method of manufacture, there are two well-known processes—Azeotropic and Salt-dehydration—both of which can be tried in India.

The mixture of petrol and alcohol does not appear to present any serious difficulties. The best and the practical method of effecting this appears to be, for alcohol to be transported in bond from the various places of production, to places where there are bulk installations by the distributing agencies for effecting alcohol-petrol mixture, the actual mixing being done in a suitable manner, as may be decided upon to safeguard the interests of the Excise Department.

The Committee is of opinion that the other uses which molasses could be put to, e.g., for the surfacing of roads, for feeding cattle, and for reclaiming *usar* soils, are still in the experimental stage, and the various problems connected with them have not been sufficiently worked out.

The Committee therefore feels that from the economic point of view, the most profitable outlet for molasses—an important by-product of the sugar industry now running almost to waste—is in the manufacture of alcohol required for power generation and for other industrial purposes. It is also convinced that several other industries, such as the manufacture of commercial organic solvents, acetic acid, chemicals requiring alcohol as one of the raw materials or ingredients in their manufacture will develop in the country with the establishment of the power alcohol industry.

There can be no doubt that in modern times the production of motor fuel is a matter of vital importance to every country, and it would be desirable if India developed her resources for the production of a motor fuel which can be pressed into service, if and when necessary, for purposes of speeding up the mechanization of the army, and the development of air-craft. The early establishment of the power alcohol industry on a sound basis will enable India to become an object of strength not only to herself but also to the Empire.

77. The members of this Committee desire to place on record their high appreciation of the services rendered to the Committee by Dr. N. G. Chatterji, who combined the functions of a Secretary with those of a member. His wide knowledge, deep insight into the problems before the Committee, and his capacity for hard work have been of great use to them.

The Committee also desires to record its appreciation of the services so willingly rendered by Mr. G. D. Tripathi, the Stenographer.

The members of the Committee also desire to record their sense of gratitude to Lala Padampat Singhania, the Chairman of the Committee, for his courtesy, patience, and tact throughout its deliberations.

PADAMPAT SINGHANIA (*Chairman*).
*N. R. DHAR.
G. H. DICKSON.
R. ANANTHASUBRAMANYAM.
*P. S. MAKER
*M. P. GANDHI.
S. S. BHATNAGAR.
N. G. CHATTERJI (*Secretary*).

CAWNPORE:
Dated June 15, 1938.

N. G. CHATTERJI,
Secretary.

*Signed subject to the note attached.

Note by Dr. N. R. Dhar

Molasses as a manure—In Java attempts have been made since 1911 to utilize molasses as a manure. Applying 1,600 gallons of molasses per acre an increased yield of paddy to the extent of 43 per cent. has been obtained in that country. In Mauritius, in Antigua, and in Queensland increased yield of sugarcane has also been reported. In the Bundeberg Farm in Queensland, Dr. Kerr obtained 37·1 tons of sugarcane per acre of land with 10 tons of molasses as manure whilst without molasses the yield was 22·7 tons per acre.

An increase in the yield of 36 per cent. has been reported of sugarcane at the Shahjahanpur Government Farm on applying 10 tons of molasses per acre. Messrs. Parry and Company, Limited, Madras, have also obtained an increase of 40 per cent. Several trials at Allahabad show that molasses produces highly beneficial result in the yield of paddy. But where molasses is added to the growing crop, no beneficial result is obtained. The value of molasses as a manure is chiefly due to the presence of carbohydrates, potash, phosphate, and calcium salts. The carbohydrates when added to the soil are oxidized and cause fixation of atmospheric nitrogen in the soil. Moreover, the same substances also help in the conservation of soil nitrogen. As the sugars have to be oxidized in the soil for the increase of nitrogen, there should be an interval of about 1 month or 5 weeks between the application of molasses and sowing of the crop. The cases of failures appear to be due to the neglect of the time factor required in the fixation of atmospheric nitrogen.

I am of the opinion that molasses should be used in improving the yield of paddy and sugarcane when applied 4 to 5 weeks before the sowing at the rate of about 10 tons per acre.

Molasses in usar (kallar) land reclamation—It is estimated that the total area of *usar* land in the United Provinces alone is more than 5,000,000 acres. Dr. J. A. Voelcker, who examined the extent of alkaline land in Northern India, stated in his "Improvement of Indian Agriculture" London, 1893, page 55, as follows: "Enormous areas, especially in the plains of Northern India, are thus affected, and in the North-West Provinces alone there are between four and five thousand square miles of *usar* land." In the Punjab, in Bihar and in the South of India, there are vast tracts of such unproductive lands. Naturally, the reclamation of these lands is a problem of great importance to India. The salts, which made these lands unfit for growing crops, are the carbonate, sulphate and chloride of sodium; sodium carbonate is chiefly responsible for the unproductiveness of such lands, which are generally heavy clay soils and are very often termed *Pattiar* waste lands.

As early as 1871, the Irrigation Department of North-West Provinces was trying to reclaim *usar* land and in 1877 a "Reh" Committee was appointed to investigate the problem. Subsequently, experiments were started at Awa in 1879, at Cawnpore in 1882 and at Aligarh in 1885. Unfortunately, as no qualified chemist was associated in these experiments no substantial results were obtained as is evident from the following letter of 13th November, 1935:

"*Usar* reclamation experiments were carried out by this Department at Juhi (Cawnpore) and Abbaspur (Unao) without appreciable results and the *babul* plantations at the places were transferred to the Forest Department."

The late Dr. J. W. Leather, who was the Imperial Agricultural Chemist, carried on the analysis of the scrapings from *usar* fields near Aligarh and other parts of United Provinces and also tried to reclaim *usar* by applying gypsum. His results show that no wheat grows on soils containing 0·008 per cent. to 0·082 per cent. sodium carbonate even when treated with gypsum.

Leather's conclusions (Investigation on *Usar* Land in the United Provinces, by J. W. Leather, Allahabad, 1914, page 37) are as follows:

(1) The only experiment which can claim to have really reclaimed the *usar* land is the application of gypsum. The cost of sufficient gypsum to affect this was very great—about Rs.700 to Rs.800 per acre—and is obviously prohibitive. Even if the cost of gypsum could be reduced to one-half (what was employed cost about Rs.20 per ton), it would still be too expensive if required in the quantity that this land did require it.

(2) The effect of deep and good cultivation coupled with heavy manuring has not been either what is indicated to the unaided eye nor what might have been anticipated. The surface foot of soil has been apparently reclaimed, but below this the soil is as bad as ever.

(3) Scraping off the salts is practically useless.

Defects of alkali lands—The chief defects of alkali land are—

(1) *High alkalinity*—We have examined several samples of bad *usar* lands and we find that the pH is as high as 10·8. Neither azotobacter nor nitrite-formers are observed in cultures obtained with these soils.

(2) The amount of calcium compounds is less in these soils than in normal ones.

(3) The nitrogen content is small. In several samples examined by us the total nitrogen varied from 0·008 to 0·02 per cent. (normal soils contain 0·05 to 0·1 per cent. nitrogen).

(4) The soil is highly impermeable to water.

(5) The soil particles do not settle readily when shaken with water and become sticky.

(6) The soil lacks bacterial activity and organic matter.

Molasses containing acids, carbohydrates, soluble calcium salts, phosphates, potash, etc., can readily remove all these defects of alkaline lands.

Alkaline lands have been successfully reclaimed near Cawnpore, Allahabad, and in Mysore by the application of molasses at the rate of one to ten tons per acre and good crops of paddy and barley have been grown in these reclaimed areas, where no vegetation ever grew. The amount of molasses necessary for reclamation depends on the quality of the alkali soil.

The cost involved in reclaiming *usar* land by treatment with molasses appears to be less than what it is with either gypsum or sulphur.

Statistics show that only 0·75 acre of land under cultivation is available *per capita* in India as against 2·6 acres in United States of America and 2·3 in France. It appears that very little land under cultivation is available in this country and land reclamation is of vital importance for the welfare of the masses of India. I am of opinion, therefore, that as there is a future

for the application of molasses in alkali land reclamation, the Agriculture Department of the Provincial Government should go ahead with this problem of reclaiming *usar* land by the application of molasses.

My recommendations in this connection are—

(1) Molasses should be used as manure for the cultivation of paddy and sugarcane.

(2) The Agriculture Department should go ahead with alkali land reclamation by the application of molasses and grow paddy and barley in the reclaimed lands.

N. R. DHAR.

APPENDIX I

A Note on Some of the Properties of Motor Fuels containing Alcohol

A—Alcohol fuels and Power Development

1. *Heat value of combustible mixtures in the engine and power output*

Pye, in his "Internal Combustion Engine," 1931 (page 54), has shown that the calculated power of an engine would be proportional to the heat generated per standard cubic foot of the mixture sucked into the cylinder, multiplied by the volume ratio on combustion, which is the ratio of the number of molecules of the various products of combustion to those of the combustible mixture. This may be regarded as potential source of increased power from an engine; the higher the ratio the greater the assessment of the value of the mixture as a working substance.

By way of illustration, we may take the case of heptane, C_7H_{16} of calorific value 10,700 C.H.U. per lb. and Ethyl alcohol, C_2H_5OH, of 6,540 C.H.U. per lb. The combustion of the correct fuel-air mixtures, together with the heat generated, is as follows:

(i) $2C_7H_{16}+22O_2+82{\cdot}8N_2=14CO_2+16H_2O+82{\cdot}8N_2+2{\cdot}155\times10^6$ C.H.U.
(ii) $2C_2H_6O+6O_2+22{\cdot}6N_2=6H_2O+4CO_2+22{\cdot}6N_2+0{\cdot}605\times10^6$ C.H.U.

Hence, the quantities of heat generated per mol of the fuel-air mixture are:—

(i) For heptane: $\frac{2{\cdot}155\times10^6}{106{\cdot}8}=20{,}180$ C.H.U.

(ii) For alcohol: $\frac{0{\cdot}605\times10^6}{30{\cdot}6}=19{,}750$ C.H.U.

Taking into consideration the volume ratio of the products of combustion to the initial gas mixtures, the total energy of the fuel-air mixture would be—

(i) For heptane, with a volume ratio of $\frac{112{\cdot}8}{106{\cdot}8}$ or 1·056:

$$20{,}180\times1{\cdot}056\times\frac{1{,}400}{359}=83{,}100 \text{ ft.-lb. per standard cubic foot.}$$

(ii) For ethyl alcohol with a volume ratio of $\frac{32{\cdot}6}{30{\cdot}6}$ or 1·065:

$$19{,}750\times1{\cdot}065\times\frac{1{,}400}{359}=82{,}200 \text{ ft.-lb per standard cubic foot.}$$

It would thus be seen that even though the calorific value of a substance is considerably lower than that of another, the correct combustible fuel-air mixture may have practically equal energy content on account of a smaller proportion of air required for combustion and consequently lesser dilution with the inert nitrogen. It is rather interesting to find that in the case of all the more common liquid fuels, the energy content of a correct mixture is almost identical, as shown in the following table compiled by Ricardo.*

Substance	Specific gravity at 15°C	Lower calorific value in C.H.U.		Latent heat of vaporization C.H.U. per lb.	Ratio by weight in correct mixture	Volume ratio on combustion	Heat liberated per S.C.F. of correct mixture	Total energy per S.C.F. of correct mixture C.H.U.
		Per lb.	Per gallon					
Petrol ..	0·70	10,130	79,200	73	14·6	1·047	57·0	59·7
Heptane (97 per cent.)	0·69	10,700	73,900	75	15·1	1·056	56·9	60·1
Benzol ..	0·88	9,610	85,200	95	13·2	1·013	57·6	58·1
Ethyl Alcohol (pure).	0·79	6,540	51,800	220	8·07	1·065	56·6	60·3
Rectified spirit (95 per cent.)	0·815	6,040	48,900	216	8·1	1·065	51·5	58·0

* Pye; "Internal Combustion Engine", page 212.

18·7 per cent. and should reduce the indicated fuel consumption by 15·7 per cent.

Compared to gasoline in a 5·45-1 compression ratio engine, the alcohol engine with a 8-1 compression ratio would theoretically require 35 per cent. more fuel by weight and 31 per cent. more fuel by liquid volume.

2. The following results were obtained by Professor Wawrziniok* in experimenting with 96 per cent. spirit and petrol in different makes of motor car engines. The engines were of the following make:

	Power	Compression ratio	Volume of the engine cylinder
I.—Daimler, motor lorry	35 H. P. ..	1·9	5·5 litres.
II.—Adler, private car	10/30 H. P. ..	4·2	2·62 ,,
III.—Elite, ditto	10/40 H. P. ..	5·5	3·14 ,,

The results are tabulated below:

Engine	Fuel	Effective power developed by—		Average consumption of fuel	
		500 r.p.m.	1,000 r.p.m.	Kg/H.P.—hr.	Litre/H.P.—hr.
..	(a) 96 per cent. spirit	17·1	27·1	0·317	0·630
	(b) Petrol	18·5	31·25	0·331	0·410
		800 r.p.m.	2,000 r.p.m.		
II ..	(a) 96 per cent. spirit	10·80	21·10	0·515	0·759
	(b) Petrol	11·75	28·00	0·113	0·590
		700 r.p.m.	2,000 r.p.m.		
III ..	(a) 96 per cent. spirit	14·2	37·60	0·512	0·626
	(b) Petrol	25·0 (1150 r.p.m.)	38·05	0·317	0·161

*Mitteilungen der Technischen Hochschule, Dresden, IV Sammelband, Tables I and IV.

3. Experiments conducted at the Yale University during 1934-35 showed that in a multi-cylinder Chevrolet engine, about 50 per cent. more fuel was required, when 95 per cent. spirit was used in place of petrol.

B—Properties relating to the Inflammability of Alcohol and Petrol

1.—*Flash Points*:

'Dangerous Petroleum' (Indian Petroleum Act)—	Below 76°F.
(a) Absolute alcohol	55·3°F.
(b) Rectified spirit—	
60° O. P. (91·4 per cent. by volume)	36·3°F.
50° O. P. (85·5 per cent. by volume)	39·5°F.
40° O. P.	61·2°F.
30° O. P.	66·0°F.
20° O. P.	70·0°F.

10° O. P. (62·8 per cent. by volume) .. .. .. 72·0°F.

Proof spirit (57·1 per cent. by volume) .. .. .. 74·0°F.

(c) Alcohol denatured with 0·5 per cent pyridine and 0·5 per cent. light caoutchoucine—

60° O.P. .. .. 56·3°F.

50° O.P. .. .. 62·0°F.

2. *Temperatures of Spontaneous Ignition.*

(Moore—J.S.C.I.—1920)

Fuel	Sp. Gr.	In oxygen	In air
Petrol	·710 to ·729	270°C—279°C.	361°C—390°C.
Lamp oil	·787	253°C.	367°C.
Alcohol (95 per cent.)	·817	305°C.	518°C.
Turpentine..	..	275°C.	275°C.

3. *Limits for the Downward propagation of Flame. Air and Fuel Mixture*

	Lower limit	Upper limit
Alcohol	3·05	13·05
Petrol	2·4	4·9
Turpentine	0·73	..

This shows that explosion wave is formed with a leaner mixture in the case of petrol. Incidentally, it also shows that in an alcohol engine the strength of the mixture may be varied within wider limits without causing miss-firing.

4. *Vapour Tension—*

	10°C. mm	20°C. mm	30°C. mm	40°C. mm	50 mm
Alcohol 100 per cent.	44	78	140	221	
Alcohol 90 per cent.	39	75	135	221	
Alcohol 80 per cent.	..	73	133	221	
Petrol, grade I	90	133	185	265	320

5. *Loss in weight of various fuels by passing air for 5 minutes at 25°C*

Petrol (0·700)	20·5 per cent.
Alcohol (95 per cent.)	1·9 per cent.
Alcohol (80 per cent.)	1·85 per cent.

This shows that, if air at 15°C be bubbled through alcohol, the quantity of vapour taken up is insufficient to form an explosive mixture. Air bubbled through hexane or benzene takes up so much vapour that the mixture is richer than the upper explosion limit for these substances.

6. "The miscibility of alcohol and water must obviously reduce greatly the risk of fire during storage and transport, since burning alcohol can be immediately extinguished if sufficient water be at hand to reduce it below a certain strength. This would, however, not apply to mixtures of alcohol and petrol." (Monier William's "Power Alcohol"—page 255.)

C—Hygroscopicity of Alcohol Fuels

It has also been established that the extent of miscibility of alcohol and petrol are regulated by the three following more important factors:

(i) The lower the strength of the alcohol from the "Absolute" grade, the more difficult it is to form a homogeneous mixture.

(ii) The lower the temperature to which the mixture is subjected, the greater is the tendency for the latter to separate.

(iii) Petrols of different origin exhibit different extent of miscibility with alcohol of the same strength.

As a rule, the higher the specific gravity of petrol, the poorer is its miscibility, though this is not strictly true in every case, for the presence of aromatics in petrol seems to favour the miscibility, but that of the naphthenes has the opposite effect.

It therefore follows that a perfectly homogeneous mixture of alcohol and petrol may have a tendency to become first opalescent and finally to separate into two layers on account of one or both of the following reasons, namely, (i) lowering in the strength of the alcohol due to gradual absorption of water from the atmosphere, or (ii) a fall in temperature of the surroundings.

A study of the literature on the subject revealed that a number of careful experiments had been conducted in this direction. The results of some of the more important of those having a direct bearing on the point at issue are summarized below:

1. *Absolute alcohol is only slightly more hygroscopic than rectified spirit*

Soriette (Chemie et Industrie, May 1923) made an experiment to compare the hygroscopic properties of technical absolute alcohol and of rectified spirit under identical conditions when exposed to an atmosphere of relative humidity 80 per cent. and temperature 15°C. His results showed that in 21 days the absorption of water was 5·1 by absolute alcohol of 99·7° G.L. and 4·35 by rectified spirit of 95·5°.

2. *The hygroscopicity of an alcohol-petrol mixture is very low and of little practical consequence*

(a) Hubendick (Spiritusmotoren, page 28, Table XXI) has shown that the extent of miscibility of heavy petrol and alcohol of different strength can be judged from the following table giving the temperatures at which separation just begins to take place

Mixture in volume per cent.		Temperature in° C of opalescence with spirit of strength				
cohol	Petrol	99·7	99	98	97	96
		under	under			
10	90	—30	—18·4	+15·4	+28	+30
20	80	—30	—26	+9·8	+22·5	+30
30	70	—30	—30	+2·6	+12·6	+30
40	60	—30	—30	+3	+10·5	+24·3

(b) Contant and Mariller (Bull. Assoc. Chim. Suc., et Distill. 1923 page 298) prepared a Mixture of 15 per cent. by volume of 99·9° absolute alcohol and 85 per cent. heavy petrol. Of this mixture 170 c.c. were exposed in an open glass vessel of 450 c.c. capacity, 160 mm. high with mouth of 34 mm. diameter, in a room containing air of humidity 80 per cent. The extent of water absorption was indirectly estimated by finding the temperature at which milkiness (showing incipient separation) took place. They found that after 43 days of exposure, the mixture had to be cooled to—8°C. to produce any milkiness.

(c) Inginеer Eckström (Hubendick's Spiritusmotoren, page 30) made several experiments which consisted in adding to mixtures of "Shell" petrol and absolute alcohol (99·5 per cent.) at a temperature of 17·5°C. such quantities of water as are needed to cause the mixture to become opalescent and finally to separate into two layers. The following table gives the results of his experiments:

Composition in volume per cent.		Specific gravity	Addition of water in per cent. to the mixture		Percentage of decantation	Degree of alcohol in the separated layer	Percentage of petrol in the separated layer
Alcohol	Petrol		Opalescence	Separation			
10	90	0·7350	0·26	0·33	2·3	96·3	20·0
20	80	0·7123	0·70	0·70	7·3	95·9	40·9
30	70	0·7491	1·20	1·30	32·0	95·3	56·2
50	50	0·7592	2·70	2·80	92·0	94·2	47·1

A little reflection would show that on the assumption that 0·76 per cent. of water is required to bring about separation in a 80 : 20 mixture, it would require 345 c.c. of water to get into the fuel tank of a motor car containing 10 gallons of the mixture before any separation is likely to take place. Such an accident is not likely to happen normally.

"The incidental admixtures of water which sometimes happen are in fact very insignificant. For instance, it was shown that the amount of water remaining inside a 5-litre petrol tin after it has been washed and carelessly rinsed, does not exceed 2 c.c., that is 0·05 per cent. And experiments have proved that this quantity is insufficient to bring about separation even in the case of a fuel containing only 2·5 per cent. alcohol. The danger of separation of alcohol fuels has thus been very much exaggerated.

"It seems strange that these efforts are obstinately limited to considering exclusively the consequences of a possible admixture of water to fuels containing alcohol without thinking of the trouble such an admixture may create in case of pure petrol. The least admixture of water to petrol occasions the formation of a layer of *pure* water which settles down in the pipe and stops the running of the engine. On the contrary, if the petrol contains even 5 per cent. of alcohol, the addition of even 45 c.c. of water to 10 gallons of the carburant does not bring about separation at ordinary temperatures. Separation takes place only at about 0°C., but the aqueous layer separating contains enough alcohol and petrol to keep the engine running." (Charles Schweizer- "Power Alcohol Question in Its Present State". Niort, 1937.)

Commenting on the experimental results quoted above, Professor Hubendick said that the lower aqueous layer was mainly composed of alcohol

contains such a percentage of petrol that the mixture, even in its separated condition, would be able to keep the engine working. Consequently, if by accident a small quantity of water gets into the fuel tank, no trouble whatever should be feared in the running of the engine.

Mr Petrilli, before the International Congress of Industrial Chemistry, Paris, 1926, described his experience in this connection in the following words:

"We purposely added to the tank of our motor car, containing 20 litres of 50/50 petrol-alcohol mixture, 200 c.c. of water, without any the slightest effect being noticeable in the working of the engine."

APPENDIX II

Note by the Secretary, Imperial Council of Agricultural Research, dated the 29th September, 1933, on Subject No. 2: Utilization of Molasses—Power Alcohol.

At its fifth meeting held in March, 1933, the Sugar Committee considered certain representations regarding the increasing difficulties encountered by sugar factories in India in finding an outlet for their molasses. The Committee came to the conclusion that the power alcohol question was most important and recommended that the Secretariat of the Council should take up the matter unofficially with the departments of the Government of India concerned. A summary of the present position by the Agricultural Expert to the Council is attached (Annexure).

2. The question as to the next step to be taken is now for the consideration of the Sugar Committee. It is suggested that the matter might conveniently be referred to a sub-committee to meet and report during the present session of the Sugar Committee.

ANNEXURE

Our examination of this question in consultation with the other departments of the Government of India concerned has brought out the following points:

(*a*) Alcohol used for motor spirit must pay the same duty as petrol. It is not possible for Government to agree to the loss of revenue which any other course would involve, nor would it be reasonable to protect the sugar industry indirectly at the expense of the indigenous oil industry.

(*b*) The question of the cost of production of power alcohol from Indian molasses is of fundamental importance and before legislation would be justified, a fuller study of the economics of the question is essential. The landed cost of petrol in bulk *ex-duty* (and before any distributing costs have been incurred) is approximately 4 annas to 5 annas per gallon. If power alcohol is more expensive than this, the price of the mixture will be higher than the present price of petrol.

(*c*) The question of distribution arrangements and costs is of great importance. The sugar factories, and thus to a considerable extent the distilleries, are remote from the ports and thus from the centres from which petrol is distributed and where mixing could best be done: they are also remote from the areas of greatest petrol consumption.

(*d*) In the event of legislation being introduced requiring a certain percentage of quantity of alcohol to be used, price control might be necessary to protect the consumer.

(*e*) The possibility of other forms of assistance than legislation for compulsory mixing should be examined.

(*f*) In view of the experience of other countries, the technical difficulties should be fully studied.

2. In regard to the cost of production, it should perhaps be emphasized that alcohol for mixing with petrol must be about 99½ per cent. absolute at least, i.e., *practically anhydrous*, otherwise difficulties due to water separation

(Modified by more recent information)

AUSTRALIA—A mixture of 17 per cent. alcohol 83 per cent. petrol is used on a small scale—legislation contemplated.

AUSTRIA—Compulsory mixing legislation brought into force from July, 1931. The motor fuel is to contain at least 20 and at most 40 parts by weight of power alcohol. The price of the mixed fuel is to be based on the price of power alcohol fixed by the State (about 80 Austrian shillings per 100 litres in 1935). Power alcohol is free from excise duty.

BRAZIL—The Law of April 1, 1931, makes it obligatory to mix 10 per cent. power alcohol to petrol. This has recently been brought into force when a sufficient number of power alcohol distilleries got established. Power alcohol is exempted from the payment of any kind of tax or duty.

CHILE—The Decree of September 28, 1933, fixed the quantity of power alcohol to be purchased by all importers of petrol at 6·25 per cent. of the quantity of petrol imported, the price of alcohol being fixed by the State. The percentage to be taken may be varied annually up to a maximum of 25 per cent.

ENGLAND—Specially denatured alcohol for use as motor fuel has not to pay any excise duty, and moreover enjoys a "Methylation Allowance" of 8·9*d*. per gallon. The Chancellor of the Exchequer has so far refused to put any duty on power alcohol in spite of repeated question in the Parliament, though it was admitted that the loss of revenue due to the exemption from tax of alcohol used as motor fuel was about £30,000 for the year 1934-35.

EQUADOR—The Decree of December 6, 1933, makes it compulsory for all petrol to be mixed with 20 per cent. its weight of power alcohol. This is for the purpose of helping the producers of sugarcane.

HUNGARY—Petrol over ·735-S.G. must be mixed with 20 per cent. alcohol (unless used for agricultural purposes); about 90 per cent. of the motor fuel used is this "Motalco".

(2) The duty on light petrol (below ·735-S.G.) is 4*d*. per gallon higher than that on "Motalco".

IRISH FREE STATE—The Government have taken up the control of the manufacture of industrial alcohol and commercial trading in the product. A number of distilleries have been erected within the last two years.

ITALY—Under the Four Years' Plan, all industrial alcohol produced from sources other than vine and fruits are under State control. All petrol must be mixed with 20 per cent. of power alcohol, the production of which was about 21·8 million gallons in 1936, and is expected to reach double the figure in 1938. Power alcohol is exempted from many of the duties levied on petrol.

LATVIA—The mixture of 25 per cent. alcohol 75 per cent. petrol is compulsory. The alcohol is a State monopoly.

PANAMA—The Decree of August 17, 1933, (i) put the duty on the mixed fuel containing 25 per cent. power alcohol at half the rate on straight petrol and (ii) fixed a maximum sale price for the mixed fuel.

PHILIPPINES—The mixed fuel is made by the sugar manufacturers and forms about one-third of the total quantity of motor fuel sold in the country. The mixed fuel is sold cheaper than petrol.

POLAND—The Law of July 2, 1932, created the State monopoly for alcohol, empowering the Government to impose compulsory mixing of power alcohol to petrol. There has so far been no necessity to impose this, as an agreement was reached by which the petroleum syndicate would buy alcohol for mixing with petrol to the extent of 9 per cent. of the quantities sold, and put the mixed fuel on sale in the country.

SWEDEN—There is no legal regulation, but power alcohol is free of all duty. The mixture used is 25-75. The quantity of alcohol used for motor fuel is about 2·5 million gallons.

YUGOSLAVIA—The Ordnance of November 22, 1933, repealed the Decree of September 27, 1932, making it compulsory to mix 20 parts of power alcohol with 80 parts of petrol. The mixed fuel is favoured by the imposition of a heavy duty on petrol, from which power alcohol is exempted.

FRANCE—At the present time, the three principal fuels used in France for motor vehicles are the following:

Touring spirit—This can be either a pure petrol, or mixtures of petrol and absolute alcohol with or without benzol. The presence of the alcohol is not obligatory. The proportion of alcohol lies between 11 and 15 per cent. of the volume of the hydrocarbons. Its octane number should not be less than 60.

Heavy spirit—This must consist of a mixture of petrol and alcohol. The proportion of alcohol is 25 per cent. of the volume of the petrol. Its octane number should not be less than 62.

Super spirits—These are used principally by the owners of modern cars with a very high compression. Their constitution depends largely on the ingenuity of the manufacturers. Actually they nearly always contain a certain proportion of absolute alcohol. Their octane number should be at least equal to 75.

7. It will be seen that whilst in several countries the use of a specified mixture has been made compulsory in others the principle has been adopted of requiring the oil companies, by law, to buy annually a quantity of power alcohol corresponding to a certain percentage of their imports and production of petrol and benzol; in some countries also of their kerosene. This method leaves the petrol distributing companies a considerable amount of latitude in distribution and in practice the mixture is sometimes sold at a lower price than pure "light" petrol despite the fact that it actually costs more. This modification is worth consideration—it would be essential that, at any rate until considerable experience has been gained, the compulsory purchase percentage should not be placed too high.

8. Another modification of the compulsory mixing method is to require all heavy petrol (i.e. all petrol), below a certain density (S.G. ·735 in Hungary) to be mixed with alcohol and to make light petrol relatively expensive by a heavier duty; this is the method adopted in Hungary, the price differential being about 4*d.* per gallon. The applicability of this method to India is doubtful where heavier petrol is used: the petrol usually distributed is of a specific gravity of about 0·752 at 30°C (equivalent to about 0·765 at 15°).

9. Yet another method of encouraging the use of alcohol as a motor fuel is the remission of duty as in Sweden—this method must be ruled out for financial reasons.

10. The conclusion seems inevitable that the admixture of alcohol with petrol will raise the price of the mixture above that of pure petrol. This is due to the fundamental fact that under the most favourable circumstances the cost of production of alcohol is several times the cost of production of petrol—including delivery by sea to ports in bulk. The figures given below would seem to indicate that the cost of mixture containing 20 per cent. of alcohol will be something like 7 annas per gallon *at the ports made up as follows:*

	Annas
0·8 gallon petrol at 5 annas	4
0·2 gallon alcohol at 11 annas	2·2
Freight on ·2 gallon of alcohol for say 600 miles at 2 annas and ·3 pies per gallon.	0·6
Total ..	6·8

Duty and distributing costs being the same, cost of petrol would be increased by about 2 annas per gallon. At up-country centres the difference would be appreciably less if mixing stations were suitably sited, though there would naturally be an increase in distributing costs with an increase in the number of mixing stations. It is clear that the cost of production and distribution of power alcohol in India require considerably more accurate determination before legislation could be proposed.

11. *Technical considerations*—Certain difficulties have been met with in other countries but appear to have been got over. The main facts may be summarized as follows:

(1) For successful admixture with petrol, alcohol must be of at least 99½ per cent. purity; 98 per cent. spirit will not do (this is clearly shown by Brazil and Cuban experience as well as by experiment). Modern plant for the production of anhydrous alcohol can produce by this distillation a purity of 99·8 to 99·9 per cent.

(2) Mixtures of alcohol and petrol for successful commercial use must be between comparatively close limits. Mixtures containing less than about 15 per cent. alcohol are unworkable for several reasons whilst mixtures containing above 20—25 per cent. call for special engine adjustments and the fuel consumption is higher.

(3) Alcohol absorbs water readily and the addition of quite small quantities of water to an alcohol-petrol mixture results in separation and cloudiness. Fortunately these difficulties are mainly met with at low temperatures and the percentage of water required to produce separation is higher with increased alcohol content; this is illustrated by the following figures:

Composition of mixtures	Percentage of water sufficient to cause separation	
	At 0°C.	At 10 °C.
Alcohol 10 per cent., petrol 90	0·25 per cent.	0·20 per cent.
Alcohol 15, petrol 85	0·50 „	0·40 „
Alcohol 20, petrol 80	0·60 „	0·48 „

Figures are also required for +10°C and for mixtures up to 25 per cent. alcohol—these determinations could easily be made.

It is clear that the degree of concentration of the alcohol used is of very great importance as the separation of a watery layer, e.g., at pumps would mean the loss of a considerable proportion of the added alcohol. For example, at 24°C with a 20/80 mixture once separation has begun, 1 per cent. of water would cause about 12 per cent. of alcohol to separate out.

(4) Information is required as to the rate at which different petrol-alcohol mixtures will absorb moisture under Indian conditions of storage, temperature and humidity. These data would be essential to the formulation of a distribution scheme.

(5) For a given power output more alcohol is necessary than petrol due to the lower calorific value of the former. In practice the addition of 15 per cent. alcohol leads to no noticeable increase in fuel consumption, an addition of 30 per cent. alcohol means an increase in consumption of about 10 per cent. This would not be a serious consideration with a 20/80 mixture since alcohol is a good "anti-knock" fuel.

12. Whatever form legislation might take, it is clear that Government might have to fix the sale price of power alcohol and possibly the price of the mixture. The cost to the consumer must be determined before legislation could be proposed. Hence the most important requirement at present is to get accurate figures for the cost of producing anhydrous alcohol in India. The type of plant required and most suitable to Indian conditions has to be settled; also the difficulties, if any, in operating it have to be ascertained. It is understood that the Mysore State contemplated experiments of this nature and it might be possible to secure their co-operation in obtaining the necessary data. If not the question of providing an experimental factory somewhere in British India will have to be taken up. The oil companies are willing to co-operate in the distribution of power alcohol if a workable scheme can be devised and doubtless their co-operation could be secured during experimental distribution at some such centre as Delhi. Power alcohol would have a freight advantage of about $3\frac{3}{4}$ annas per gallon and the cost of the mixture would be (omitting duty and distribution charges):

	Annas per gallon
0·8 gallon petrol at 8 annas	6·4
0·2 gallon alcohol at 11 annas	2·2
Total	8·6

as compared to petrol at 8 annas so that the addition to the price of petrol would be small.

The first step, therefore, is to get an experimental scheme going in some suitable area.

B. C. BURT.

The 22nd September, 1933.

Statement showing the petrol sales in the various provinces for the years 1929, 1930 and 1931

Province	Gallons		
	1929	1930	1931
Madras	10,331,000	11,248,000	10,696,000
Bombay	11,936,000	12,971,000	13,182,000
Bengal	9,913,000	10,076,000	10,782,000
United Provinces	3,753,000	4,476,000	4,553,000
Burma	7,623,000	7,756,000	7,137,000
Shan States	550,000	663,000	621,000
Punjab	4,602,000	5,397,000	5,560,000
Bihar and Orissa	2,537,000	2,910,000	2,736,000
Central Provinces	2,317,000	2,660,000	2,247,000
Assam	1,285,000	1,599,000	1,764,000
North-West Frontier Province ..	1,263,000	1,514,000	1,660,000
Rest of British India and Indian States ..	9,767,000	11,460,000	11,723,000
Total ..	65,877,000	73,660,000	72,661,000

(In round figures corrected up to the nearest thousand gallons.)

APPENDIX III

Production of Alcohol from different sources in various countries

In Hectolitres of 100° G.L. Alcohol

Country	Year	From beet	From molasses	From potato	Total from all sources (round figures)
1. Austria ..	1936–37	..	141,200	..	201,000
2. Belgium ..	1932	..	80,300	..	167,000
3. Czechoslovakia ..	1933	54,000	250,000	506,000	968,000
4. Denmark ..	1936	..	25,000	35,000	94,000
5. England ..	1932	..	500,000	..	738,000
6. France ..	1935–36	2,863,300	1,088,400	..	5,827,000
7. Germany ..	1936–37	..	127,743	2,331,000	3,634,000
8. Hungary ..	1934	.. ..	..	..	303,000
9. Italy	1936	383,500	328,000	..	1,005,000
10. Philippines ..	..	..	178,000	..	179,000
11. Poland ..	1933	..	11,000	257,000	269,000
12. Yugoslavia ..	1931	..	118,000	31,000	140,300

APPENDIX IV

Consumption of Alcohol (in Hectolitres) for different purposes in various countries

(Modified from Mons. Collerot's Paper to the III International Congress of Technical and Agricultural Chemistry, Paris, 1934)

Country	Year	For drinking and flavouring wine	Vinegar making	Perfumery	Chemical industries	Heating and lighting	Motor fuel
1. Austria	1933	72,230	7,323	210	5,180	71,507	4,000
2. Belgium	1932	63,800	15,000	4,976	22,581	14,800	140
3. Czechoslovakia.	1932	162,000	20,062	..	11,035 (1)	181,781 (2)	586,116
4. Denmark	1935	15,176	..	..	19,718	51,050	..
5. England	1933	230,000	..	10,000	..	507,000	17,800
6. France	1932-33	1,365,366	50,781	111,032	195,353	722,050	1,937,938
7. Germany	1936-37	680,379	131,134	41,376	..	565,101	1,823,686
8. Hungary	1934	23,700	15,100	..	20,800	43,900	98,900
9. U.S.A. ..	1933	Prohibition	130,000	30,000	951,000	806,000	..

Remarks—(1) Industrial spirit and (2) Denatured spirit.

(Note—1 Hectolitre = 22 Imperial gallons.)

APPENDIX V

Consumption of power alcohol in various countries

(Ind. and Eng. Chem., News Edition, 20th July, 1936)

	Country	Year	Quantity in Imperial gallons	Remarks
1.	Austria	1934 ..	1,018,000	
2.	Brazil	1935 ..	10,455,000	
3.	Cuba	1934 ..	2,367,000	
4.	Czechoslovakia	1934 ..	13,190,000	
5.	France	1934–35 ..	81,624,000	
6.	Germany	1936–37 ..	40,121,000	
7.	Hungary	1934 ..	2,100,000	
8.	Italy	1934 ..	1,402,000	Rapid increase since 1934.
9.	Latvia	1934 ..	1,350,000	
10.	Poland	1934 ..	1,700,000	
11.	Spain	1935 ..	2,400,000	
12.	Sweden	1934 ..	2,400,000	
13.	United Kingdom ..	1935 ..	1,242,000	

APPENDIX VI

Comparative prices of power alcohol in various countries in 1936

(Tokayer, "World Petroleum," 7th June, 1936)

Country	Price of power alcohol per gallon	
	In American cents	Equivalent in Indian currency
		Rs. a. p.
1. Austria	57	1 10 3
2. Czechoslovakia	76	2 3 0
3. France	27	0 12 0
4. Germany	76	2 3 0
5. Hungary	79	2 4 4
6. Italy	88	2 8 6
7. Jugoslavia	40	1 2 5
8. Latvia	59	1 11 2
9. Poland	19	0 8 9
10. Spain	52	1 7 11
11. Sweden	31	0 14 3

APPENDIX VII

Alcohol-petrol mixed fuels in different countries

Country	Commercial name of the mixed fuel	Composition			Whether alcohol mixing is compulsory
		Petrol	Benzol	Alcohol	
1. Austria ..	..	80	60	20—40	Yes.
2. Australia ..	Shellkol ..	85	..	15	No.
3. Brazil ..	..		..	..	Yes.
4. Bulgaria ..	..	75—70	..	25—30	Law not enforced.
5. Chile ..	..	..		..	Yes.
6. Cuba ..	Motuco ..	37	3	60	No, but favourable.
7. Czechoslovakia	Dynalkol(1)	(*i*) 80 (*ii*) 70	.. 4	20 26	Yes.
8. Denmark ..	..	75	..	25	No, but State monopoly.
9. England ..	Cleveland Discol.	70	15	15	No, but favourable.
10. Equador ..	..	80	..	20	Yes.
11. France ..	..	Various proportions			Yes, State monopoly.
12. Germany ..	Monopolino	Ditto			Ditto.
13. Hungary ..	Motalko ..	80—70	..	20—30	Yes.
14. Italy ..	..	80		20	Yes.
15. Lettonia ..	Latol ..	(*i*) 50 (*ii*) 67	..	50* (1) 33(2)	Yes, State monopoly.
16. Lithuania ..	Motorin ..	75	..	25	Yes.
17. Natal ..	Natalite ..	50	..	50	No, but favourable.
18. Panama ..	..	80	..	20	Ditto.
19. Philippines	Gasanol ..	70	..	30	
20. Poland ..	..	(*i*) 85—70 (*ii*) 15—30	..	15—30*(3) 85—70(4)	No, State monopoly.
21. Swedon ..	Lattbentyl	75	..	25	No, but favourable.
22. Yugoslavia ..	..	80		20	Legislation favourable.

*(1) Summer time mixture.
(2) Winter time mixture.
(3) For motor cars.
(4) For tractors.

APPENDIX VIII

Power alcohol plants installed in various countries

Country	Azeotropic process (1)		Salt-Dehydration process (2)	
	Number	Capacity per day (*In hectolitres*)	Number	Capacity per day (*In hectolitres*)
1. Argentine	1	300	..	..
2. Australia	1	150	..	..
3. Austria	1	220	..	..
4. Belgium	3	400	..	..
5. Bulgaria	..	..	2	180
6. Brazil	13	2,750	3	190
7. Chile	2	120	..	..
8. Columbia	..	..	2	60
9. Czechoslovakia	24	3,230	14	1,360
10. Denmark	1	40	..	..
11. England	3	580	..	..
12. France	15	14,635	2	1,200
13. Do. Colonies	5	430	..	..
14. Germany	10	3,900	1	300
15. Holland	1	3	..	..
16. Hungary	6	700	..	..
17. Irish Free State	5	150	..	..
18. Italy	11	3,455	1	40
19 Lettonia	2	440	..	..
20. Lithuania	1	75	..	..
21. Panama	1	40	..	..
22. Poland	3	510	..	..
23. Portugal	1	60	..	..
24. South Africa	3	360	1	60
25. Spain	1	30	4	900
26. Sweden	1	30	2	180
27. Yugoslavia	5	425	2	280
Total ..	163	32,959	34	4,750

(1) Information available up to the end of 1936.
(2) Information available up to 1935.

APPENDIX IX

I—Properties of petrol marketed in Europe and India

Petrols	Sp. Gr. at 60°F	Initial B. P. °C.	Per cent. by vol. up to 100°C	Final B. P.°C	Octane number
I—Standard Oil Company Petrols imported into European countries					
1. Premium grade* ..	0·745—0·770	30°—35°	40—45	Below 200°	80
2. Standard grade ..	0·725—0·735	30°—35°	40	Below 200°	66
3. Heavy grade (Commercial).	0·710	35°	28—33	200°	64
II—Petrols marketed in the United Kingdom					
1. No. 1 grade* ..	0·732—0·743	32°—41°	38—42	185°—197°	70—72
2. No. 3 grade (Commercial).	0·737—0·749	34°—38°	32—36	190°—205°	65—66
III—Petrols marketed in India					
"A"	0·741 at 30°C.	38°	31	215°	64—67
"B"	0·729 at 30°C.	48°	47	194°	67—69
"C"	0·714 at 30°C.	42°	53	191°	..
"I"	0·738 at 30°C.	44°	30	183°	65—67
"S"	0·740 at 30°C.	43°	30	205°	..
IV—Alcohol fuel marketed in England					
	At 60° F.				
Standard grade (containing 15—20 per cent. alcohol).	0·750—0·755	38°—46°	51—56	195°	76

* Sometimes contains Tetraethyl Lead.

II.—Properties of Racing Fuels containing Alcohol

(Marketed in United Kingdom by Solvents Products, Limited)

Specific gravity at 15°/15°C	0·828	0·822
Hydrocarbons	23%	10%
Acetone	Trace	9%
98 per cent. Ethyl Alcohol	77%	79%
Initial Boiling Point	68·5°C.	64°C.
95 per cent. Distillate at	78°C.	78°C.

(Nash and Howe—"Motor Fuel." Paragraph 816)

APPENDIX X

Consumption or sale of petrol in 1937 in some district towns

(In 1,000 gallons)

UNITED PROVINCES	
Lucknow	601
Cawnpore	580
Allahabad	301
Agra	299
Meerut	265
Muttra	257
Benares	220
Bareilly	165
Aligarh	149
Jhansi	113
BIHAR	
Bankipore (Patna)	293
Jamshedpur	286
Ranchi	205
Gaya	192
Dhanbad	164
Hazaribagh	145

APPENDIX XI

Note on the denaturation of power alcohol

The denaturation of such alcohol is a matter of great importance.

The ideal denaturant should possess the following properties.

The Ideal Denaturant

1. It should be a volatile, combustible liquid soluble in alcohol (and petrol), having an unpleasant taste and smell and not easily separable from the spirit by physical or chemical means so that regeneration of alcohol for drinking purposes is practically impossible.

2. It should be harmless for the industrial purposes for which the alcohol is used.

3. It should contain an "earmarking" substance so that, if potable alcohol is regenerated from the denatured alcohol, it would make it possible to identify the origin of the regenerated potable alcohol.

4. It should be relatively cheap.

5. It should be available in large quantities.

6. For India it is desirable that it should have no deleterious effect on the human system.

Denaturants used in various countries

The denaturants used for power spirit to be used as motor fuel in various countries are as follows:

	Per 100 litres of alcohol
Bulgaria—	
Crotonaldehyde	0·2 gm.
Chile—	
Petrol	5 litres
Ethyl borate	20 c.c. (containing 0·2 grm. of boron).
Czechoslovakia—	
Methyl alcohol	2 litres per 98 litres of ethyl alcohol.
Petrol	3 "
Denmark—	
Methyl spirit	2 litres
Pyridine bases	0·5 "
Petrol	0·25 "
England—	
Ethyl alcohol	92 parts
Wood naphtha	2½ "
Pyridine	½ "
Petrol or benzol	5 "
Spirit red III dye	¼ oz. by weight per 1000 gallons.

This mixture is issued in the United Kingdom free of duty or restriction when mixed with 25 per cent. of petrol, benzol, denatured ether or some other substances approved by the Commissioners of Customs and Excise.

APPENDIX XIII

Purchase and sale prices of alcohol transacted through the State monopoly of Germany

PRICES OF SPIRIT DURING 1937-38

Purchase prices

(a) For distilleries with a regular production up to 600 hls. (both yeast factories and molasses distilleries)—		
For 50 per cent. of the annual production	..	52·00 Rm.
For over 50 per cent.	..	40·00 „
(b) For distilleries over 600 hls.	..	46·00 „
For molasses distilleries	..	42·00 „
For yeast factories	..	39·50 „

Sale prices

Drinking spirit	..	400·00 Rm.
(a) Fully denatured spirit	..	45·00 „
(b) Industrial spirit (partially denatured)	..	40·00 „
Motor spirit	..	39·25 „
Acetic acid making spirit	..	85·00 „
Spirit for toilet preparations	..	240·00 „
Export spirit	..	20·00 „

N.B.—During this period the price of molasses varied between 3·00 and 3·09 Rm. per 50 Kg., equivalent to about Rs.2 6 per maund.

APPENDIX XIV

Production of molasses in cane factories during 1936-37

(Based on a statement supplied by the Director, Imperial Institute of Sugar Technology)

Province and district	Quantity (in 1,000 maunds)	Number of factories	Remarks
UNITED PROVINCES			
Dehra Dun	88	1	
Saharanpur	87	1	
Muzaffarnagar	401	4	
Bijnor	427	5	
Meerut	598	8	
Bareilly	301	3	
Etah	101	1	
Pilibhit	210	1	
Kheri	200	2	
Shahjahanpur	60	1	
Sitapur	337	3	
Bara Banki	61	1	
Lucknow	57	1	
Gonda	287*	3	*One factory did not submit its figures.
Basti	381	5	
Gorakhpur	1,731†	22	†Four factories did not submit their figures.
Jaunpur	66	1	
Allahabad	53	1	
Hardoi	112	1	
Deoria	82	1	
BIHAR			
Champaran	1,023	8	
Saran	922	10	
Muzaffarpur	315	3	
Darbhanga	605	6	
Bhagalpur	8	1	
Purnea	83	1	
Shahabad	358	4	
Patna	152	1	
Gaya	83	1	

APPENDIX XV

Distilleries in the United Provinces and Bihar

Name of distillery	Proprietor or Managing Agents	Remarks
UNITED PROVINCES		
1. Cawnpore Sugar Works, Limited.	Messrs. Begg, Sutherland & Co., Limited, Cawnpore.	Patent Stills.
2. Unao Distillery ..	The Punjab National Bank ..	Patent Still (not working at present).
3. Lucknow Distillery ..	M. Dyer Meakins Breweries, Limited.	Patent Stills.
4. Rosa Distillery ..	M. Carow & Co.	Ditto.
5. Meerut Distillery ..	The Central Distillery and Chemical Works, Limited, Meerut.	(To start shortly.)
6. Indian Distillery, Cawnpore	L. M. B. L. Singhania, Cawnpore	Patent Still.
7. Fyzabad Distillery ..	The Fyzabad Distillery Co., Limited.	Pot Stills.
8. Allahabad Distillery ..	The Allahabad Distiller's Association, Limited.	Ditto.
9. Saharanpur Distillery ..	The Co-operative Co.'s, Limited..	Ditto.
BIHAR		
1. Cawnpore Sugar Works, Limited, Marhowrah (district Saran).	Messrs. Begg, Sutherland & Co., Limited, Cawnpore.	Patent Stills.
2. Manpur Distillery (Gaya)..	K. B. Chowdhury Muhammad Baksh, Manpur.	Ditto.
3. Manikatha Distillery (district Monghyr).	M. Lakshmi Narain Ram Narain, Manikatha.	Ditto.
4. Ranchi Distillery ..	Ditto ..	Ditto.
5. Sultanganj Distillery (district Bhagalpur).	Khan Bahadur Habibur Rahman, Sultanganj.	Ditto.

APPENDIX XVI

A—Production of industrial alcohol in India in 1936-37

	Methylated spirit (Calculated in gallons of absolute alcohol)	Rectified spirit
United Provinces	270,000	24,000
Bihar	103,000	..
All-India	1,325,000	235,000

B—Import of denatured spirit into India

Year	Quantity (gallons)	Value
		Rs.
1934–35	413,429	5,58,224
1935–36	206,405	3,25,462
1936–37	337,426	2,75,609
1937–38	379 010	3,14,012

APPENDIX XVII

Some interesting data regarding power alcohol plants and their working (Compiled by the Secretary)

(1) A 1,000-ton cane crushing factory produces about 4,550 tons of molasses during one season.

(2) A distillery producing 1,500 gallons of power alcohol requires about 25 tons of molasses per day.

(3) The capital cost required for a complete power alcohol distillery with building and with a rated daily capacity of 1,500 gallons is about Rs.2,60,000.

(4) The cost of supplementary plant (Melle Azeotropic system, capacity 1,500 gallons per day) for manufacturing power alcohol from rectified spirit made in a modern patent still distillery is about Rs.35,000.

(5) Working data for the plant may be taken approximately as follows:

(i) Consumption of steam

	Per gallon of power alcohol
(a) When rectification and dehydration carried separately ..	52—56 lb.
(b) When direct from fermented wash	32—36 lb.

(ii) Loss of the "entraining liquid"

Used in Azeotropic process	0·0004—0·00045 gallon.

(iii) Consumption of cooling water

(a) Salt-dehydration process	9—12 gallons.
(b) Azeotropic process	30—34 gallons.

(6) A 1,500 gallon distillery produces enough carbon dioxide to turn out about 3·5 tons of dry ice per 24 hours.

APPENDIX XVIII-A

Report from the Agricultural Chemist in Mysore, Bangalore, forwarded under his letter no. A.C.837/37-38, dated 21st/22nd February, 1938

Question 1—Have you or your department any experience in the use of molasses as (i) manure for ordinary soils growing common crops, like rice, wheat, sugarcane, etc.?

If so, please give details of its economic aspects.

Answer—Very little—a few pot experiments and small-scale plot trials were conducted. The results were hardly encouraging. Paddy and ground-nut were the crops under test. In view of the inconclusive results obtained further experiments are under way.

Question 2—Have you any experience of the use of molasses in the reclamation of *usar* (alkaline soils) in India? If so, kindly give as far as possible details of the field and large-scale experiments conducted in this direction giving—

(*a*) Amount of alkali in the soils.

(*b*) The amount of molasses and the number of application required to get the optimum results.

(*c*) The period for which the land so treated may continue to be in a fit condition for agricultural purposes.

(*d*) Whether it results in any ultimate harmful effect (after some years) to the soil thus treated.

Answer—Yes, purely experimental and exploratory. Copy of *letter to the Director of Agriculture, United Provinces, is enclosed which covers most of the points raised in (*a*) and (*b*). As regards (*c*) and (*d*), no opinion can now be advanced as we are still experimenting.

Question 3—What are your views in general regarding the utilization of molasses in India for the above two purposes? To what extent are you prepared to advise the Committee to recommend the use of molasses for these purposes under the present agricultural and economic conditions in India based on the experimental work done so far in this country?

Answer—Molasses can be used for reclaiming *usar* soils. The only objections to this, so far as we know are—

(1) the cost of transport,

(2) the extreme discomfort to man and beast in its application to land, and

(3) the time-lag period which must elapse after application of molasses before the land is fit for cropping.

*See Annexe.

ANNEXE

Copy of the letter no. 712-3/Encl. 2, dated 2nd February, 1938, from the Bio-Chemist, Agricultural Laboratories, Bangalore, to the Director of Agriculture, United Provinces, Lucknow

I AM desired by the Director of Agriculture to acknowledge with thanks your letters no. 13098/1—544(B) of 20th December, 1937 and 14724/1—373 (A)104 of 17th December, 1937. The delay in replying is deeply regretted.

As is to be noted from my letter no. AC. no. 430/17—18 of 4th November, 1937, to Professor N. R. Dhar, D.Sc., of Allahabad, our experiments in the first instance have been purely qualitative and largely exploratory of the possible use of molasses for reclaiming alkali soils.

A bad patch of 17 acres of alkali land on the Government Farm at Mandya—Mysore—with a pH varying from 7·5 to 9·0 was selected and planned to be cropped with paddy. The land was treated with 2 to 3 tons of molasses per acre not less than 9 to 12 weeks before transplanting flooded and ploughed dry at least 3 to 4 times. A bulk crop of paddy was then taken. During the first year, a small crop of 476 lb. of paddy grain per acre was obtained and a re-treatment of the land during the following year gave a grain yield of 1,250 lb. per acre. The yield of straw was equally good. A third untreated crop of 1,250 lb. paddy grain was harvested during 1936-37 and the yields of the current year are awaited. It may be mentioned that the land in question has had no other crop grown on it and had little or no vegetation at all prior to being "molassed". Few stray blades of grasses appeared in pocket of low alkalinity and the rest of the land was distinctly bare. These qualitative experiments were so encouraging that a further 6 acres of land of high alkalinity are under treatment.

As regards trials on *ryot's* lands, the results have hardly been satisfactory as returns have not been reliable. A more organized collection of returns are in contemplation and will be taken up during the coming year.

As stated earlier all these experiments have been purely qualitative and exploratory. It was only at the beginning of this year that two sets of experiments (i) to study the optimum dose of molasses for reclamation and (ii) to study its fertilizer effect were started. These experiments have been laid out in a randomized latin square, a well recognized statistical method. A preliminary soil survey of the plots in question had been done with reference to the nature and degree of alkalinity and the initial fertility level.

For the reclamation experiments, paddy has been selected and will have a rotation of fodder *jola* (*Sorghum*) sann-hemp and paddy. Molasses varying from 0 to 4 tons per acre has been applied and a paddy crop is now standing on the plots. Results will be communicated immediately they are available. There are four treatments and four replications. The pH of these soils have been from 7·5 to 9·0.

As regards experiments on the use of molasses as a fertilizer, a few qualitative studies in the earlier years using paddy or ground-nut were inconclusive and hardly encouraging. Experiments have however been laid out during the current year on approved statistical lines with ground-nut as the test crop. The trial consists in measuring the fertilizer effect of molasses

against a standard mixture of fertilizer on the one hand and that of molasses and fertilizers on the other. The crop is yet to be harvested and the results are therefore not yet available. These also will be communicated as soon as they are ready. An unmanured cotton crop will be taken up on these plots after harvesting ground-nut and preparing the land. Fertilizer trials with paddy as a test-crop are also in contemplation and will be conducted during the coming year. It may be mentioned in passing that the pH of these plots are round about ±7, i.e. somewhere near neutrality. It is also necessary to add that all these experiments are being conducted in an irrigated tract; no experiment in dry lands are under way.

With reference to the economic use of the question, I regret to say that we are as yet unable to give a definite opinion. It may however interest you to know that this aspect of the question was discussed in some detail at a Symposium on "Cane Molasses" under the auspices of the society of Biological Chemists—India, held in Bangalore early in September, 1937. It was then agreed on all sides that the use of molasses in its present form was only possible within a limited distance from source (e.g. a sugar factory) and that means should be found to minimize the time-lag that must occur before any cropping can be done after an application of molasses to the land. A summary of the papers presented at the meeting together with a brief synopsis of the discussion has been published as a bulletin of the Society. Their Headquarters Office at Hebbal—Bangalore, may be addressed with advantage for a copy of the same. I may add that Professor N. R. Dhar has recently suggested the use of a mixture of equal quantities of press-mud and molasses which is expected to diminish the discomfort involved in the use of molasses on the field. Trials on this are being arranged.

APPENDIX XVIII-B

Report from D. R. Sethi, Esq., M.A., B.Sc. (Edin.), I. A. S., Director of Agriculture, Bihar, Patna, forwarded under his letter no. 1373/V—24-38. dated 31st January, 1938.

With regard to the question of cattle food, it is doubtful if molasses as cattle food would be utilized to any large extent by the cultivators. In their raw form, molasses cannot be used for this purpose. They have to be turned out in some suitable manner mixed with other fodders so that they could be transported and handled easily. The economics of feeding molasses as cattle food as compared to other materials such as oil-cakes have also yet to be worked out, and until detailed experiments are carried out on this important point and definite results achieved, it would be, in my opinion, not right to make any broad recommendation on this point.

With regard to the use of molasses as a fertilizer, I should like to point out that the experimental work carried out by this Department so far indicates that while the molasses from sulphitation factories do give positive results on light soils in this province, the carbonitation molasses definitely depress the yield. A clear distinction will, therefore, have to be made so far as Bihar is concerned that only sulphitation molasses are useful as a manure. The economics of molasses as fertilizers yet remain to be worked out. We have so far been working on the basis that molasses have no value at present and can be had for the asking. Once this material finds a widespread use as a manure, the factories would be perfectly justified in asking for a reasonable price. Whether the use of this material at a price as fertilizer would be equally as economical as other manures has yet to be investigated. The greatest difficulty in the widespread use of this material as a manure appears to me to be the extreme difficulty in transporting and handling. While it may be quite easy for a sugar factory to use this stuff on its own cane lands, the average cultivator will find it rather difficult to transport it to his fields which may be situated anything from 2 to 10 miles away from the factory. Indications are that molasses may prove of very great assistance in reclaiming alkaline soils. Here again the quantity that could possibly be used would be limited by the area that could be reclaimed and brought under cultivation.

APPENDIX XVIII-C

Report from Dr. B. K. Mukerji, Ph.D., D.Sc., Agricultural Chemist to Government, United Provinces, Cawnpore, forwarded under his letter no. 810 R.C./I.B., dated 9th February, 1938.

1. *Molasses as fertilizer*—The Department of Agriculture of the United Provinces started in the year 1932 investigations regarding the use of molasses as manure for ordinary soils. The experiments have been confined mainly to the sugarcane crop, and conducted at Shahjahanpur, Cawnpore, Gorakhpur, Bahraich and Muzaffarnagr. The investigations at Cawnpore also included a trial with wheat.

The data so far available indicate that molasses must be applied at the rate of about 10 tons per acre two months before sowing sugarcane in order to gain appreciable increase in the outturn. As regards the sucrose content, there is in the case of planted cane no significant difference between the canes obtained from the molasses-treated plots and those from the unmanured plots. With ratoon canes, molasses has given higher yield at Gorakhpur and Cawnpore, and fares favourably with fertilizers at Muzaffarnagar. This increase is statistically significant as compared to control, but the sucrose content with the molasses treatment is definitely lower than with the no-manure treatment.

With wheat our experience has been that molasses gives a lower yield than either dung or compost although it is appreciably higher than the control.

Molasses is generally supposed to promote nitrogen fixation in a normal soil, but this is not consistently realized in actual practice as is evident from the conflicting results obtained by us.

As is well known, apart from the intrinsic merits of any fertilizer, the cost at which it is available to the cultivators makes all the difference between its success and failure. In the case of molasses we have also to bear in mind the cost of transport in addition to its price per maund at source. Even if the factory price is as low as annas 2 per maund, the purchasing cost of 10 tons molasses alone would come to about Rs.34-4. Add to that the cost of transport which is approximately Rs.2 per ton for a distance of 10 miles from the factory, the total cost of 10 tons of molasses, meeting the requirements for only one acre, works out under the most economical conditions to Rs.54-4. In view of the high cost it is extremely doubtful whether the additional gain in the shape of increased outturn would be commensurate with the expenditure on account of the molasses applied to the soil.

It might be noted here that while success is recorded at Bangalore, negative results have been obtained for sugarcane at Padegaon (Bombay-Deccan) and Risalewala (Punjab). Experiments with paddy conducted at Sabour (Bihar) during the year 1934-35 failed to establish the superiority of molasses over the no-manure treatment even though the dose of molasses was equivalent to 20 lb. nitrogen or 8,000 lb. per acre.

2. *Reclamation of usar (alkaline) soils by molasses*—Small scale experiments conducted by the Agricultural Chemist to Government, United Provinces, some years ago showed that molasses had a definite ameliorative effect upon *usar* soil from the Cawnpore District. More detailed work upon this is being conducted by Professor Dhar in co-operation with the Department of Agriculture, United Provinces These experiments have not been in progress

sufficiently long to warrant any expression of opinion on either of the points, 2(*c*) or (*d*) raised in the questionnaire, that is, whether molasses brings about a lasting improvement or if it causes by prolonged application any harmful effect on the soil.

During Professor Dhar's absence from India a field experiment on systematic lines was laid out during the last *kharif* season by the Agricultural Chemist at the Government Model Farm, Unao, to study the effect of applying molasses to *usar* land on the outturn of rice. The soil which is typically *usar* having a pH value (alkalinity) 9·3—9·6, was treated three weeks before transplantation of paddy with molasses at the rate of (i) 5 tons, (ii) 10 tons and (iii) 15 tons per acre. Two more treatments, one control and the other press-mud at the rate of 5 tons per acre, were also included. All the 5 treatments were laid out in four randomized blocks, the area of each sub-plot being 1/40th acre. The yield figures have now been statistically treated both in regard to grain and straw. The main conclusions are as follows:

(*a*) *Grain*—(i) Molasses at 10 tons per acre gives highest yield of grain, and

(ii) There is no significant difference among the grain yields obtained with 5 or 15 tons molasses, 5 tons press-mud and the control.

(*b*) *Straw*—(i) Molasses at 15 tons per acre gives the highest yield of straw and molasses at 10 tons comes next.

(ii) There is no significant difference in the straw yields between the 5 tons molasses and the 5 tons press-mud treatments; but either of these is superior to control which shows the poorest yield.

Of all the treatments in this experiment, molasses at the rate of 10 tons per acre appears on the whole to be the best. Although there are *priori* reasons to believe that it would be necessary for the satisfactory reclamation of *usar* land to apply molasses at the rate of about 10 tons per acre, yet it is too early to say anything about the number of applications which may be required to get the optimum results.

Here again, it is clear that much of the ultimate success of the method would depend on the cost involved. The total cost of 10 tons of molasses at the rate of only 2 annas a maund, ex-factory, will be as shown above at least Rs 54-4. If the price of molasses be more than 2 annas a maund or if more than one application becomes necessary, then there would obviously be a proportionate increase in the total cost of the treatment.

Excepting for the experiment referred to above, I am not aware of the detailed results obtained from any other large-scale field trial which might have been systematically undertaken in the United Provinces or elsewhere to assess the value of molasses for reclaiming alkali lands. In the Punjab the application of molasses to *kallar* (alkali) soil has failed to yield satisfactory results, whereas it is recorded that by systematic treatments with calcium salts, such as gypsum and calcium chloride, those soils have improved considerably within three years.

3. *General*—On account of the high cost as shown above, molasses does not promise to be of great value as fertilizer for ordinary crops in normal soils. It is extremely doubtful if the use of molasses as ordinary fertilizer could ever be recommended as an economic method of disposing of the large quantities of the stuff available in this country. It is obvious that as a nitrogenous manure, molasses is not likely to be of direct value. It

contains potash in somewhat large quantities, but even in this we would get more by conserving our ordinary wood ashes. The chief value of molasses as fertilizer can lie only in its ability to stimulate direct fixation of nitrogen. But so far our experience has been that the direct or indirect gains accruing out of the application of molasses to normal soil do not justify the cost of the treatment.

The use of molasses of reclaiming *usar* or alkali lands seems to be an interesting and useful proposition. But in this too, the limiting factor appears likely to be the considerable cost of obtaining, carting and applying the treatment. The method appears to require the application of large quantities and the permanence of the effect has not yet been established. It is, therefore, too early to launch out into any extensive application. As a concrete instance, it may be cited that in our Western Circle the proportion of *usar* to normal soil is highest in the Mainpuri District; but the cost of molasses near about Mainpuri, Etah and Aligarh being somewhat excessive, it has not been found possible to adopt the use of molasses on any large scale for reclamation purposes. Whatever molasses is available from open-pan sugar factories is being used with considerable success by private individuals in the middle Doab, notably Mainpuri and Etah districts. The method consists in leaching the soil with monsoon, well or canal irrigation water combined with the application of molasses.

It is now well known that types of mild *usar* are capable of reclamation, at least for successful rice crops, by flooding and leaching combined with the application of organic manures; either green manure, or farm-yard manure, or compost. For agricultural application this is the only method which can at present be recommended. This method has been the subject of grants-in-aid from the Board of Agriculture and by the Director of Agriculture as well as of experiments on agricultural farms and demonstration plots. Thus the Unao farm and the Bara Banki model farm were located in *usar* tracts, with a considerable proportion of *usar* soil within their boundaries, for demonstration of the possibilities of such ameliorative measures; while considerable demonstration has been conducted in the Sarda area by the co-operative effort of the Agricultural and Irrigation departments. The Unao farm has shown that *usar* soil can be reclaimed for profitable growth of rice and other crops by leaching combined with organic manuring, the application of sugar factory press-mud cake, or dressing of *nala* silt. On the Cawnpore Research Farm mild *usar* has been reclaimed without heavy leaching by cultural methods including the growth of deep-rooted legumes, green manuring, or trenching with *juar* and sugarcane roots and the like, and by manuring with large doses of compost combined with good cultivation. The demonstration of the efficiency of leaching combined with green manuring on mild *usar* has been so impressive that the Irrigation Department are providing free irrigation water, up to the surplus supplies available for reclamation by this method during the first season of operation and there has already been a response from zamindars particularly in Unao District. It is expected that the coming *kharif* will show a very much greater area under reclamation in this way.

APPENDIX XVIII-D

Report from Dr. P. E. Lander, I.A.S., Agricultural Chemist to Government, Punjab, Lahore, forwarded under his letter no. 439, dated 10th February, 1938.

I.—Experiments on the use of molasses as manure for sugarcane, wheat and cotton have been carried out by the Deputy Director of Agriculture at Lyallpur and, considering conjointly the yields of the three crops raised successfully from the same plots after the application of molasses, he was in no case able to obtain increased yields. On the contrary the application of molasses in amounts from 40—150 maunds per acre exhibited a distinct tendency to depress yields. He found that even when molasses is valued at one anna and six pies per maund, financially the application of molasses has resulted in loss.

In 1936, the Agricultural Chemist in conjunction with the Deputy Director of Agriculture carried out a fresh trial with molasses as a fertilizer for sugarcane, and kept a full record of the changes that take place in the physical and chemical nature of the soil following the use of molasses, which was applied one and two months respectively before sowing sugarcane. It was also applied in two different ways, firstly by direct addition to the soil with the irrigation water and secondly after being composted with the soil during the above period. The quantity applied was 150 maunds (5·5 tons) per acre and the chemical changes in the different nitrogenous constituents of the soil were studied at monthly intervals. The results obtained may be summarized as follows:

(1) The application of molasses resulted in a slight improvement in the texture of the soil as indicated by an increase in the water holding capacity.

(2) There was a fall in the pH value from 8·10 to 7·85.

(3) There was practically no increase in the amount of nitrogen fixed, although there was a great increase in the number of azotobacter in soil treated with molasses.

(4) As the figures given below show, the quality of the cane suffered by the application of molasses.

Analysis of sugarcane: Variety—Co 285

Percentage on cane

Manure	Juice	Sucrose	Glucose	Total solids	Glucose ratio	Purity co-efficient
Control	59·8	9·36	0·19	10·8	5·2	86·7
Molasses applied one month before sowing.	60·6	8·61	0·47	10·5	5·1	81·8
Molasses applied two months before sowing.	60·7	8·58	0·53	10·4	5·6	82·8

(5) The outturn of sugarcane, as shown below, was adversely affected by the application of molasses:

Average yields in maunds per acre

	Cane	Gur
	Mds. srs.	Mds. srs.
Control	621 0	72 30
Molasses applied one month before sowing ..	520 10	57 15
Molasses applied two months before sowing ..	513 0	56 10

It is clear from the above that under the climatic and soil conditions of Lyallpur, the use of molasses as a fertilizer for sugarcane has a negative value.

II.—A series of trials to study the effect of molasses as a reclamation agent for alkali soils (Bari) was started at Montgomery in 1936. It is too early to draw any conclusions from the one year's results so far obtained which are given below:

Yields per acre

(From average of 6 plots, each 1/22 acre in size)

	Grain	Straw
	Mds. srs. ch.	Mds. srs. ch.
Control	0 2 12	0 9 10
Molasses at 50 mds. per acre	0 23 6	1 2 10
Molasses at 100 mds. per acre	1 2 10	2 14 4

The cost of molasses at Montgomery was 12 annas per maund, and at this value, it is extremely doubtful if the reclamation of the Bari type of alkali soil will be an economic proposition.

The abovementioned soil received an additional similar dose of molasses in 1937, and wheat was again sown last October. The results of yields will be available after April.

(*a*) The composition of the soil is as follows:

Complete chemical and mechanical analysis of Bari soil

(Per 100 parts of soil)

	Water extract analysis
Total solids	0·5935
Sodium carbonate	0·0325
Sodium bicarbonate	0·1730
Sodium chloride	0·1490
Sodium sulphate	0·2110
Calcium	*Nil.*
Magnesium	*Nil.*
Sodium	0·1603
Potassium	0·0075
	Mechanical analysis
Clay	19·30
Silt	27·28
Fine sand	52·47
Coarse sand	0·67
Kankar	*Nil.*
	Available analysis (1 per cent. citric acid extraction)
Potash	0·0609
Phosphate	0·0984

	Exchangeable basis (Milli equivalents)
Calcium (Ca)	0·65
Magnesium (Mg)	*Nil.*
Sodium	5·09
Potassium	0·04
Degree of alkalization	88
pH value	9·66 (hydrogen Elec. trode)
Organic matter	0·2480
Total nitrogen	0·0325
Total carbonates as ($CaCO_3$)	5·14

Regarding (*b*), (*c*) and (*d*) of the Questionnaire, I am not in a position as yet to make any statement.

III.—On the basis of the limited experience that I have of the use of molasses, I do not feel justified in offering any definite views regarding the utilization of the material in India for the above two purposes. The results obtained so far in the Punjab are not very encouraging. Some of the other methods of reclaiming alkali soils which I have tried seem to be more promising and economic. The indications at present are that for the Punjab soils the use of molasses by itself may not be very successful.

I still consider that, as I recommended years ago, the most effective manner of disposing of molasses would be to convert it into power alcohol.

APPENDIX XVIII-E

Report from Rao Bahadur B. Viswa Nath, F.I.C., F.C.S., Director and Imperial Agricultural Chemist, Imperial Agricultural Research Institute, New Delhi, forwarded under his letter no. 220 of 1938, dated 28th February, 1938

Question 1—Yes. I have experience in the use of molasses as manures for rice and sugarcane. The experiments with rice were carried out when I was Agricultural Chemist at Coimbatore, with the following results:

Treatment	Yield per plot of 4 cents		Yield per acre	
	Grain	Straw	Grain	Straw
	lb	lb	lb.	lb.
(1) Control	137	134	3,417	3,350
(2) Molasses—5 tons per acre	140	139	3,492	3,475
(3) Molasses—7½ tons per acre	156	137	3,888	3,425
(4) Molasses —4 tons per acre plus 1 cwt. ammonium sulphate per acre.	151	138	3,783	3,458

The increase in the yield of grain over "no manure" was significant in the cases of *(3)* and *(4)*.

The experiments with sugarcane were carried out at Pusa. The scheme of experiments is below:

(1) 100 lb. N as mustard cake + 20 lb. K_2O and P_2O_5.
(2) 100 lb. N ,, ,, ,, + 50 lb. K_2O only.
(3) 100 lb. N ,, ,, ,, + 100 lb. P_2O_5 only.
(4) 100 lb. N ,, ,, ,, + 50 lb., 100 lb. K_2O and P_2O_5.
(5) 100 lb. N as molasses and ammonium sulphate + 50 lb. K_2O.
(6) 100 lb. N ,, ,, ,, ,, ,, + 50 lb., K_2O and 100 lb. P_2O_5.

The quantity of molasses used was 1,000 lb. to the acre and analysed 5·27 per cent. K_2O, 0·5 per cent. nitrogen and 0·23 per cent. P_2O_5.

The final harvest results and analyses showed that the application of the manure was justified economically. Complete manuring gave 187 lb. of *sucrose* per plot of 0·25 acre, as against 104 7 lb. for the plot receiving no manure. The combination of ammonium sulphate and molasses gave as good a result as with mustard cake, potassium sulphate and super.

Question 2—I have not conducted specific field experiments on the use of molasses in the reclamation of alkaline soils, but from observational results, I have formed the opinion that they will do very well as correctives for alkaline lands which are not too alkaline, and in checking alkalinity. The use of molasses with gypsum is definitely more efficacious than gypsum alone in reclaiming very bad alkaline soils.

I have investigated the biological changes that take place in swampy soils. An enormous increase in the microbiological population and the production of organic acids occurs on the addition of molasses and these contribute to the beneficial effect on alkaline soils following the application of molasses.

Question 3—If it could be arranged I would unhesitatingly recommend the use of molasses in agriculture. The crop response as judged by immediate increases on application varies with conditions of soil and climate. While I am not prepared to say that crop increase would invariably follow the application, I am prepared to assert that the use of molasses does improve and build up the fertility of the soil From this point of view, I consider that molasses possess a higher value as manure than as alcohol.